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CHILD DEVELOPMENT

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WASHINGTON, D. C.
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SIZE AND BODY BUILD OF ADOLESCENTS IN RELATION TO RATE OF SKELETAL MATURING

by

NANCY BAYLEY

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SIZE AND BODY BUILD OF ADOLESCENTS IN RELATION TO RATE OF SKELETAL MATURING

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INTRODUCTION

In a companion article (3) a close relationship has been demonstrated between degree of skeletal maturity and growth in body dimensions when the latter are expressed as percentages of the individual's own mature measurements. In the present study, using the same experimental data, we shall alter the emphasis, and be concerned with the bearing of skeletal maturing, as contrasted with chronological age, on growth in absolute size. These comparisons are made in a number of anthropometric dimensions, and in developmental changes which occur in indices derived from some of these anthropometric dimensions. Skeletal age is here treated as an indicator of relative physical maturity, and complete closure of the epiphyses represents mature or adult physical status.

The data in Tables 5 and 6, in the earlier monograph (3) have indicated that there are some age changes and some sex differences in correlations between height and skeletal age. From these tables it appears, especially before 15 years, the more mature boys are taller, the less mature boys shorter, than the average. After 15 years the correlations drop rapidly, though they remain positive. Apparently the early-maturing boys tend to lose their advantage and the late-maturing boys their disadvantage as they approach maturity, but it is probable that some of the differences between early and late maturers persist and are related to differences in body build in adults. Richey, using axillary hair as a criterion of maturity, found that "Boys who mature late are not only shorter and lighter up to a late age but are lighter proportionately to their height at all ages than are those who mature early" (4, p. 61).

The correlations for the girls (3, Table 6) are quite different from those for the boys. This is in part due to the fact that they cover ages nearer to maturity. At the ages for which we have data the r's are practically zero, with a tendency to become negative with approaching maturity. From these r's we might say that at least from 13 1/2 to 14 1/2 years there is no relation between size and relative maturity, but that at the later

ages the late-maturing girls are relatively tall, the early-maturing girls relatively short.

The differences which have been shown in this general way by the correlation coefficients can be analyzed further by breaking the sample down into smaller, relatively homogeneous groups and studying the growth trends of these groups. Such groups are the early-, average-, and late-maturing ones which have been already described (3). The girls were divided on the basis of age at reaching complete skeletal maturity, or Skeletal Age (Sk. A.) 16.2 on the Todd Standards (11, 12). The boys were of necessity divided according to age at reaching Sk. A. of 17.2, or one year short of skeletal maturity. These groups in each sex are approximately one year apart in Chronological Age (C. A.) at reaching the "mature" skeletal standard. They are divided: girls 25 early-, 27 average-, and 19 late-maturing; boys 21 early-, 35 average-, and 21 late-maturing. An advantage of this procedure of grouping the cases according to age at reaching maturity, is that trends of growth for such groups can be extended back to ages earlier than those for which we have skeletal age data, and longitudinal trends in other than skeletal data may be examined from the age of 10 years through 18 years.

These maturity-groups have been compared for four anthropometric dimensions, namely: height, stem length, bi-iliac diameter, and biacromial diameter. Comparisons of the growth trends of the means of these measures for the six groups of children reflect the correlational data and indicate further differences and similarities (Table 1).

TABLE 1

MEANS AND STANDARD DEVIATIONS (S.D.) OF FOUR ANTHROPOMETRIC DIMENSIONS FOR GROUPS DIVIDED ON THE BASIS OF AGE AT REACHING SKELETAL MATURITY

GIRLS

Height (Millimeters)

	Early-Maturing			Average-Maturing			Late-Maturing		
C.A.	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S. D.
10.7	12	1446	50	12	1406	61	8	1434	79
11.2	17	1496	53	23	1442	52	11	1401	68
11.7	23	1519	59	24	1474	55	18	1437	82
12.2	22	1549	61	25	1504	54	18	1481	82
12.7	25	1568	59	26	1542	48	17	1514	80
13.2	22	1584	59	25	1572	49	18	1562	69
13.7	24	1592	55	28	1589	48	20	1576	76
14.2	25	1604	56	27	1600	49	19	1592	64
14.7	25	1611	54	26	1608	54	19	1609	62
15.2	23	1615	56	25	1616	49	18	1619	62
15.7	24	1614	56	22	1623	55	18	1636	57
16.2	23	1622	52	27	1618	52	18	1637	64
16.7	22	1620	51	25	1625	54	18	1639	66
17.2	22	1620	54	22	1635	51	19	1647	69
17.7	18	1618	57	15	1625	54	15	1649	61

TABLE 1 (Cont.)

Stem Length

C.A.	Early-Maturing N	Mean	S.D.	Average-Maturing n	Mean	S.D.	Late-Maturing n	Mean	S.D.
10.7	12	743	25	12	728	26	8	739	25
11.2	17	775	32	23	745	23	11	730	36
11.7	23	788	38	24	758	30	18	743	39
12.2	22	802	38	25	769	31	18	763	42
12.7	25	816	34	26	792	28	17	779	40
13.2	22	828	33	25	810	24	18	800	37
13.7	24	839	32	27	823	23	20	812	42
14.2	25	846	32	27	834	21	19	821	40
14.7	24	852	32	26	840	21	19	836	33
15.2	21	857	36	23	846	21	18	846	34
15.7	24	860	33	22	851	24	18	854	32
16.2	23	863	33	27	853	22	17	860	34
16.7	22	865	32	25	855	23	18	866	33
17.2	21	865	35	22	863	20	19	869	33
17.7	18	865	34	15	862	22	15	870	28
				Bi-iliac Diameter					
10.7	12	241	16	12	228	10	8	229	9
11.2	17	246	14	23	235	14	11	232	14
11.7	23	248	14	24	242	14	18	234	13
12.2	22	257	15	25	245	15	18	240	14
12.7	25	261	14	26	253	14	17	245	12
13.2	22	262	13	25	260	13	18	253	13
13.7	24	266	12	27	264	14	20	257	14
14.2	25	272	13	27	268	14	19	262	14
14.7	25	276	15	26	271	14	19	266	14
15.2	22	278	16	24	273	15	18	270	16
15.7	24	278	14	22	279	9	18	274	15
16.2	23	280	16	27	280	14	17	280	15
16.7	22	280	14	25	282	13	19	279	16
17.2	22	281	15	22	283	14	19	283	15
17.7	18	283	17	15	280	14	15	284	13
				Biacromial Diameter					
10.7	12	314	13	12	305	17	8	323	10
11.2	17	319	18	23	309	14	11	314	18
11.7	23	326	16	24	316	14	18	314	19
12.2	22	331	18	25	323	16	18	321	18
12.7	25	335	17	26	331	14	17	328	19
13.2	22	342	18	25	338	13	18	343	19
13.7	24	344	17	27	342	15	20	340	22
14.2	25	350	18	27	345	12	19	345	19
14.7	24	349	17	26	346	13	19	350	17
15.2	21	347	22	24	352	14	18	352	17
15.7	24	351	18	22	354	11	18	358	17
16.2	23	351	16	27	353	13	17	362	19
16.7	22	353	16	25	356	12	18	360	20
17.2	21	353	15	22	359	10	19	366	19
17.7	18	353	17	15	358	12	15	369	20

GROWTH RATES AND BODY BUILD OF EARLY-, AVERAGE-, AND LATE-MATURING GROUPS

a. Girls

The mean values of height for girls, when plotted against age, show (Figure 1) that the late-maturing girls as a group are short in the early ages, but become the tallest group after 15.5 years, while the reverse is true of the early-maturing girls, the average group taking the mean course throughout. This accounts for the directional trend of the correlations we have and would lead us to expect even higher positive r's at earlier ages, back at least to 9 or 10 years, when the adolescent growth spurts start. In stem length (Figure 2) and biiliac diameter (Figure 3) the same differences occur, with the exception that the groups reverse their positions at a somewhat later age. The biacromial curves (Figure 4) give a similar, though less clear-cut, picture. These findings are in general in accord with those in other studies on other groups of children (7, 10). Furthermore, they are to be expected in view of the close relation between a child's growth in size and his skeletal age, as shown in the high correlations between these factors (3, Tables 5 and 6). As the early-maturing girls approach maturity their growth slows down and stops at an age when the late-maturing girls are still growing fairly rapidly.

Figure 1

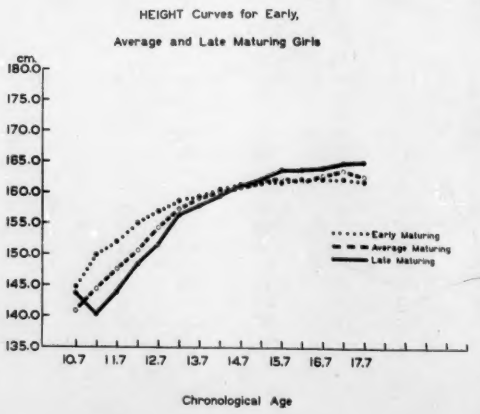


Figure 2

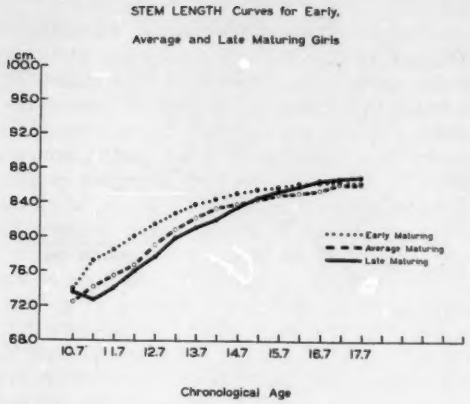


Figure 3

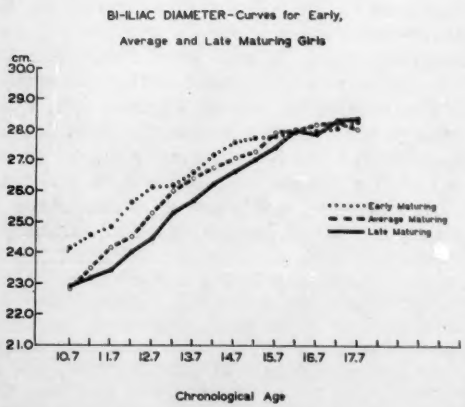
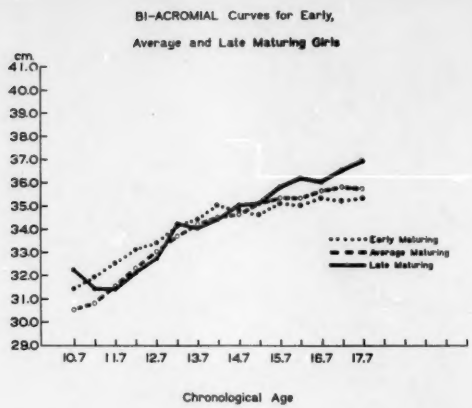


Figure 4



In Figures 1 - 4 we have compared children of the same chronological ages. The differences are clarified considerably when comparisons are made on the basis of similar skeletal maturity. This has been done, in a rough way, by adjusting the C. A. base line so that for any given point on the vertical axis the early-maturing group is one year younger and the late-maturing group is one year older than the average group.[1] This difference holds quite well at all ages, as we see in Table 2. These adjusted curves (Figures 5, 6, 7, and 8) show the late-maturing girls to be consistently large for their skeletal maturity, and the early-maturing girls to be consistently small, in all of the dimensions studied, i. e., height, stem-length, bi-iliac diameter and biacromial diameter. The differences, however, are large enough to be statistically significant

[1] A more satisfactory method would be to plot the curves of growth against actual skeletal age. However, our skeletal data are available over so short an interval and the number of cases at any skeletal age would be so small that such an operation on our data does not seem feasible. Furthermore, the method here used is comparable to those used in other studies, in which some single point (e.g., menarche) was used to "equalize" physical maturity.

Figure 5

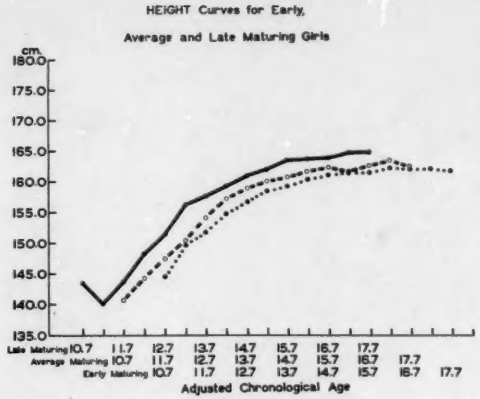


Figure 6

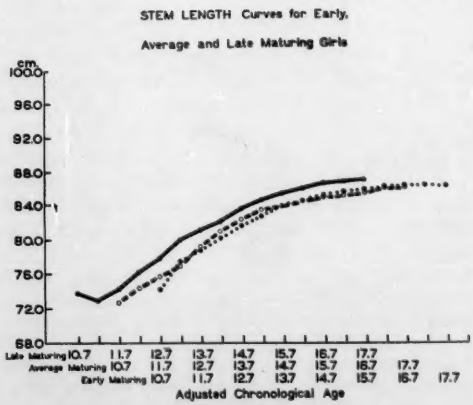


Figure 7

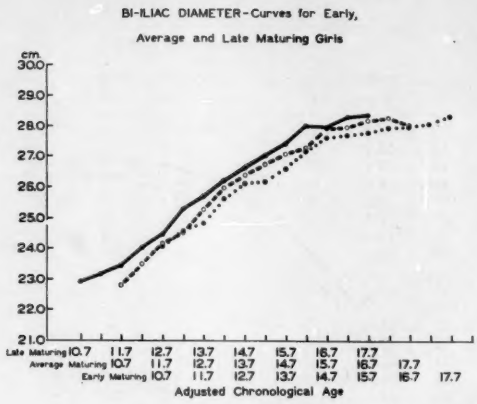


Figure 8

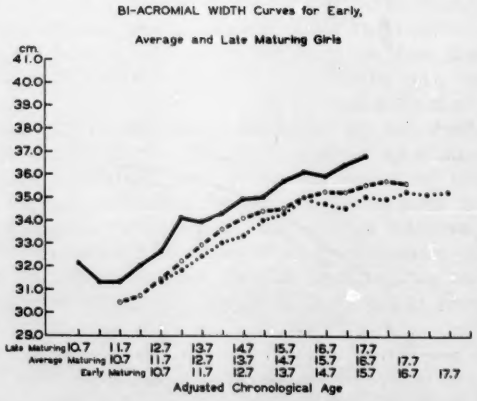


TABLE 2

MEANS AND STANDARD DEVIATIONS (S.D.) OF SKELETAL AGE SCORES AT GIVEN CHRONOLOGICAL AGES OF GROUPS DIVIDED ACCORDING TO AGE AT REACHING MATURE SKELETAL STATUS*

	Early-Maturing			Average-Maturing			Late-Maturing		
C.A.	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
BOYS									
13.7	7	14.9	.37	16	13.7	.52	6	13.1	.45
14.2	14	15.4	.55	28	14.1	.52	17	13.5	.52
14.7	18	15.9	.56	31	14.6	.57	17	13.8	.46
15.2	19	16.5	.59	34	15.3	.55	20	14.4	.56
15.7	14	16.8	.51	33	15.8	.49	21	15.0	.43
16.2	17	17.2	.51	33	16.3	.40	17	15.5	.39
16.7	15	17.8	.40	32	16.8	.43	20	15.9	.44
17.2	17	18.0	.24	31	17.4	.45	19	16.4	.33
GIRLS									
13.7	12	15.0	.77	14	13.7	.38	8	13.2	.46
14.2	19	15.6	.54	23	14.5	.51	14	13.5	.66
14.7	23	16.0	.40	26	15.1	.50	19	14.0	.65
15.2	25	16.2	.23†	26	15.4	.45	16	14.6	.53
15.7	25	16.2	-	22	15.8	.37	18	15.0	.50

*This table is the same as Table 10 in the companion monograph (3).
†Three previously mature cases placed at 16.5 Sk. A.

in only three instances, though the trends are consistent.[2] The greatest differences occur in biacromial width between early- and late-maturing girls, with the critical ratios ranging from 1.8 to 3.7, and averaging 2.5 (Table 3). From these data we may say that the girl who matures rapidly is a little more likely to be small relative to her skeletal age, and that she is more likely to be a short adult. On the other hand, the girl who matures slowly is often large for her skeletal age, and relatively broad-shouldered, and so may not seem, in pre-adolescence, very small for her chronological age. Furthermore she is more likely to become a large adult.

So much for the absolute dimensions. How do these girls compare in body build? (Table 4). It has been said (6) that broad-built girls mature early, but is this only apparently true because of their relatively mature status at 12 to 14 years when the comparisons were made? Perhaps we should say, instead, that early-maturing girls achieve their adult, broad-hipped build at an earlier age than do the late-maturing girls. The mean curves of the $\frac{\text{bi-iliac}}{\text{height}}$ indices for the three groups of girls

[2]*Such consistent trends in longitudinal studies may be due to sampling errors which persist because the sample remains constant. The conclusive test will be in similar treatment of other samples.*

TABLE 3

CRITICAL RATIOS BETWEEN MEANS OF EARLY AND LATE-MATURING GIRLS FOR FOUR ANTHROPOMETRIC MEASURES, WHEN ADJUSTED TO EQUIVALENT SKELETAL MATURITY

C.A.		Critical Ratios			
Early Maturers	Late Maturers	Height	Stem Length	Bi-iliac	Biacromial
10.7	12.7	2.8	3.0	0.7	2.2
11.2	13.2	3.2	2.2	1.5	3.7
11.7	13.7	2.8	2.0	2.0	2.5
12.2	14.2	2.2	1.6	1.2	2.4
12.7	14.7	2.2	1.9	1.1	3.0
13.2	15.2	1.8	1.6	1.8	1.8
13.7	15.7	2.5	1.5	1.9	2.6
14.2	16.2	1.7	1.4	1.8	2.0
14.7	16.7	1.5	1.4	0.6	1.9
15.2	17.2	1.6	1.1	1.2	3.0
15.7	17.7	1.8	1.1	1.3	2.8

are shown, in Figure 9, adjusted to equate the groups for skeletal maturity. The three curves overlap each other throughout the age-ranges covered in this study. Differences in hip-width relative to height are not related to rate of maturing in girls when they are equated for skeletal age. The same is true of the relative proportions of stem and legs, as shown in the

Figure 9

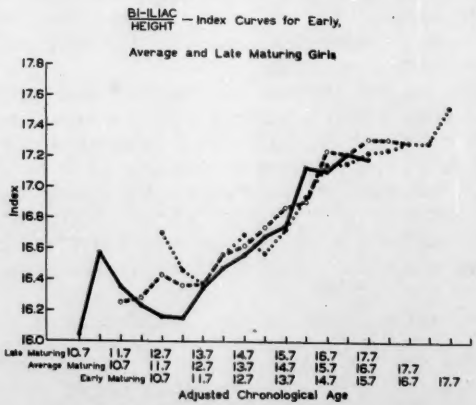


TABLE 4

MEANS AND STANDARD DEVIATIONS (S.D.) OF THREE ANTHROPOMETRIC INDICES FOR GROUPS DIVIDED ON THE BASIS OF AGE AT REACHING SKELETAL MATURITY

GIRLS

	Early-Maturing			Average-Maturing			Late-Maturing		
C.A.	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
Stem Length/Height									
10.7	12	51.4	1.1	12	51.8	1.2	8	51.6	1.4
11.2	17	51.9	1.7	23	51.6	1.1	11	52.2	0.9
11.7	23	51.9	1.6	24	51.5	1.3	18	51.7	1.1
12.2	22	51.8	1.5	25	51.2	1.2	18	51.5	1.0
12.7	25	52.1	1.4	26	51.4	1.4	17	51.4	1.0
13.2	22	52.3	1.5	25	51.5	1.2	18	51.3	1.1
13.7	24	52.6	1.5	27	51.8	1.4	20	51.6	1.1
14.2	25	52.7	1.6	27	52.2	1.3	19	51.6	1.3
14.7	24	52.9	1.6	26	52.3	1.3	19	52.0	1.3
15.2	21	53.1	1.7	23	52.5	1.3	18	52.3	1.1
15.7	24	53.3	1.5	22	52.5	1.3	18	52.3	1.3
16.2	23	53.2	1.5	27	52.7	1.2	17	52.6	1.1
16.7	22	53.4	1.4	25	52.6	1.3	18	52.9	1.0
17.2	21	53.3	1.5	22	52.8	1.1	19	52.8	1.0
17.7	18	53.4	1.3	15	53.1	0.8	15	52.8	1.1
Bi-iliac/Height									
10.7	12	16.7	.94	12	16.2	.63	8	16.0	.55
11.2	17	16.5	.84	23	16.3	.74	11	16.6	.56
11.7	23	16.4	.73	24	16.4	.75	18	16.4	.59
12.2	22	16.6	.72	25	16.4	.80	18	16.2	.55
12.7	25	16.7	.78	26	16.4	.80	17	16.2	.53
13.2	22	16.6	.76	25	16.6	.86	18	16.2	.55
13.7	24	16.7	.75	27	16.6	.88	20	16.3	.60
14.2	25	16.9	.78	27	16.7	.87	19	16.5	.61
14.7	25	17.2	.81	26	16.9	.86	19	16.6	.62
15.2	22	17.2	.86	24	16.9	.94	18	16.7	.69
15.7	24	17.2	.80	22	17.2	.71	18	16.8	.64
16.2	23	17.2	.85	27	17.2	.84	17	17.1	.70
16.7	22	17.3	.79	25	17.3	.80	18	17.1	.65
17.2	22	17.3	.90	22	17.3	.88	19	17.2	.68
17.7	18	17.5	.81	15	17.3	.82	15	17.2	.57
Bi-iliac/Biacromial									
10.7	12	77.2	4.0	12	75.0	3.3	8	71.8	1.4
11.2	17	77.4	4.6	23	75.9	5.0	11	74.7	2.4
11.7	23	76.7	4.4	24	76.5	3.8	18	74.8	3.4
12.2	22	77.5	3.8	25	75.8	3.8	18	74.7	2.8
12.7	25	78.4	4.4	26	76.3	3.8	17	74.7	3.7
13.2	22	77.2	3.8	25	76.9	4.1	18	74.1	3.2
13.7	24	77.6	4.0	27	77.5	4.4	20	75.8	3.7
14.2	25	77.8	4.1	27	77.8	4.6	19	75.9	3.3
14.7	24	79.2	4.3	26	78.3	4.5	19	76.0	3.5
15.2	21	79.9	5.4	24	77.5	3.8	18	76.8	3.8
15.7	24	79.4	4.8	22	79.1	3.4	18	76.6	3.1
16.2	23	79.8	4.2	27	79.2	3.6	17	77.4	3.0
16.7	22	79.4	3.9	25	79.1	3.6	18	77.6	3.5
17.2	22	80.0	4.3	22	78.9	3.6	19	77.4	3.9
17.7	18	80.2	4.9	15	78.4	3.4	15	76.9	3.7

$\frac{\text{stem length}}{\text{height}}$ index curves in Figure 10. There does appear, however, to be a tendency for the late-maturing girls to be relatively broad-shouldered (Figure 11).

Figure 10

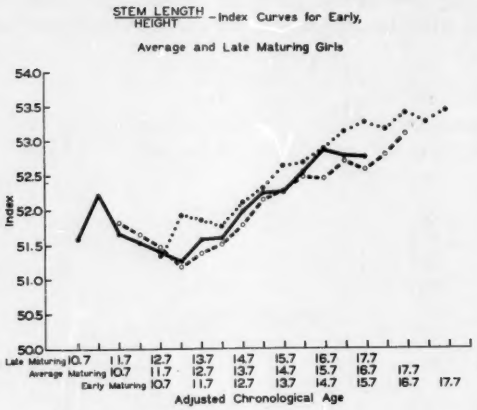
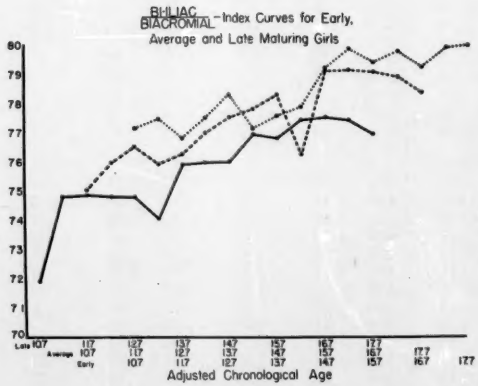


Figure 11



So far as the girls are concerned, the only differences we have discovered in relation to rate of skeletal maturing are in general size, and in a tendency for the late-maturing girls to be broad-shouldered. In these respects the late-maturing girls are built somewhat more like the boys, though the sex differences in both size and growth trends remain large. As a concomitant of their rates of maturing, girls achieve their adult build at different chronological ages, and so temporarily, at around 14 years of age, the early-maturing girls are "broad-built" in comparison with the late-maturing girls of the same age.

b. Boys

The same anthropometric comparisons have been made for the boys with somewhat different results (Table 5). When the

TABLE 5

MEANS AND STANDARD DEVIATIONS (S.D.) OF FOUR ANTHROPOMETRIC DIMENSIONS FOR GROUPS DIVIDED ON THE BASIS OF AGE AT REACHING SKELETAL MATURITY

BOYS

	Early-Maturing			Average-Maturing			Late-Maturing		
C.A.	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
Height (Millimeters)									
10.7	7	1490	53	19	1419	54	12	1421	36
11.2	13	1493	66	24	1436	60	12	1438	48
11.7	19	1512	70	30	1464	60	18	1450	49
12.2	16	1568	71	33	1488	58	18	1471	50
12.7	20	1590	83	35	1517	63	20	1495	50
13.2	19	1644	84	34	1554	70	20	1521	52
13.7	21	1687	83	33	1599	70	21	1552	55
14.2	19	1734	78	32	1636	72	20	1586	60
14.7	20	1736	74	34	1677	69	21	1624	65
15.2	17	1755	86	34	1706	63	19	1668	66
15.7	17	1778	77	33	1732	67	21	1710	60
16.2	15	1800	70	31	1748	62	18	1744	59
16.7	16	1795	58	34	1755	64	20	1757	58
17.2	15	1819	69	29	1760	68	20	1768	55
17.7	14	1821	54	23	1760	57	19	1782	54
Stem Length									
10.7	7	774	23	19	737	28	12	734	19
11.2	13	770	24	24	744	28	12	735	24
11.7	19	781	31	30	755	31	18	741	24
12.2	16	802	28	33	765	28	18	748	26
12.7	20	814	36	35	776	31	20	756	27
13.2	19	840	38	34	794	33	20	767	27
13.7	21	866	37	33	815	36	21	780	27
14.2	19	889	36	32	837	37	20	795	31
14.7	20	901	34	34	860	36	21	816	36
15.2	17	913	38	34	878	33	19	841	39
15.7	17	927	31	33	896	32	21	863	36
16.2	15	240	29	31	907	29	18	887	34
16.7	16	943	23	34	914	32	20	895	33
17.2	15	950	26	29	919	35	20	905	28
17.7	14	954	25	23	916	32	19	916	25

TABLE 5 (Cont.)

Bi-iliac Diameter

C.A.	Early-Maturing n	Mean	S.D.	Average-Maturing n	Mean	S.D.	Late-Maturing n	Mean	S.D.
10.7	7	240	13	19	225	14	12	218	11
11.2	13	237	14	24	224	14	12	226	9
11.7	19	242	13	30	230	12	18	224	10
12.2	16	252	15	33	234	13	18	229	10
12.7	20	257	15	35	238	14	20	233	13
13.2	19	264	15	34	244	15	20	237	12
13.7	21	271	14	33	250	14	21	240	11
14.2	19	278	14	32	257	14	20	246	12
14.7	20	279	10	34	263	14	21	250	12
15.2	17	283	15	34	268	14	19	259	13
15.7	17	288	15	33	273	14	21	264	11
16.2	15	290	13	31	275	13	18	272	12
16.7	16	288	10	34	276	15	20	274	11
17.2	15	291	14	29	276	14	20	275	10
17.7	14	293	13	23	278	14	19	277	10
				Biacromial Diameter					
10.7	7	311	14	19	299	17	12	296	17
11.2	13	312	16	24	303	12	12	304	16
11.7	19	318	15	30	307	12	18	304	18
12.2	16	336	18	33	313	12	18	310	14
12.7	20	338	19	35	319	15	20	314	17
13.2	19	347	20	34	326	16	20	317	17
13.7	21	361	21	33	337	16	21	321	20
14.2	19	371	20	32	346	17	20	331	22
14.7	20	378	16	34	357	17	21	337	23
15.2	18	382	21	34	364	15	19	349	23
15.7	16	392	21	33	375	15	21	360	22
16.2	15	398	22	31	381	13	18	372	23
16.7	16	398	15	34	383	15	20	376	23
17.2	15	404	23	29	386	17	20	380	22
17.7	14	407	21	23	389	18	19	388	19

three maturity groups are compared on the basis of chronological age, the early-maturing boys are consistently larger than the others at all ages, while the late-maturing boys tend to be smaller than the average between 12 and 16 years. (Figures 12, 13, 14, and 15). This is true of all four measures. The late-maturing boys appear to have fallen behind the average group in the pre-pubescent period, and only catch up as they approach maturity. There is, in fact, some indication from the upward direction of the curve at the latest measures, that in height the late-maturing group will eventually outstrip the average group and be as tall as, or taller than, the early-maturing group when they finally attain their complete growth.

When these curves are adjusted for skeletal maturity (Figures 16, 17, 18, and 19), there are no differences except a tendency for the early-maturing boys to be wider-hipped (bi-iliac diameter). With approaching maturity this latter difference becomes statistically significant, with a critical ratio of 3.2. That is, for their skeletal ages, both the early and late-maturing boys are similar in size to those who mature at an

Figure 12

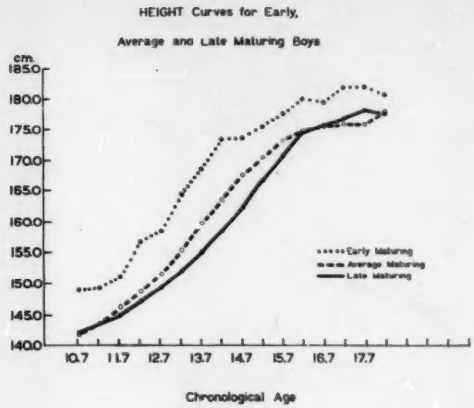


Figure 13

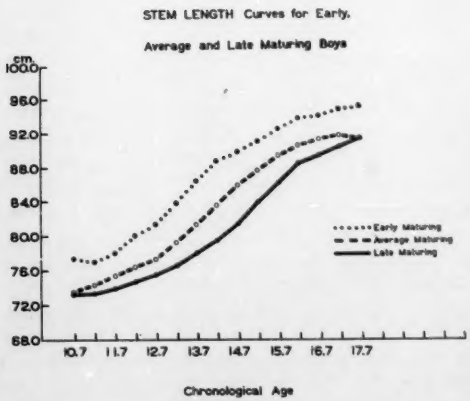


Figure 14

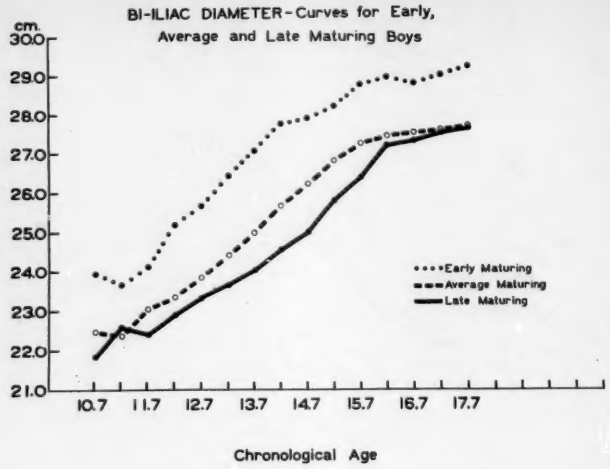


Figure 15

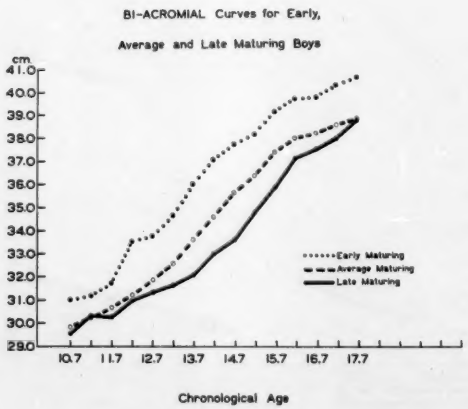


Figure 16

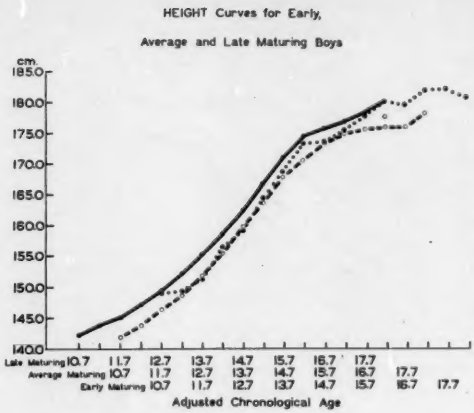


Figure 17

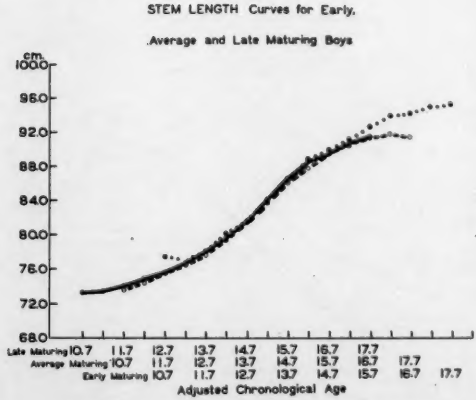


Figure 18

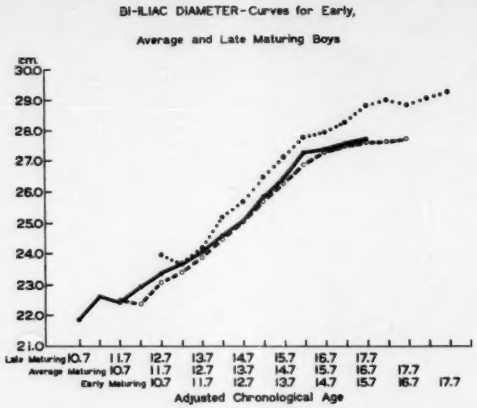


Figure 19

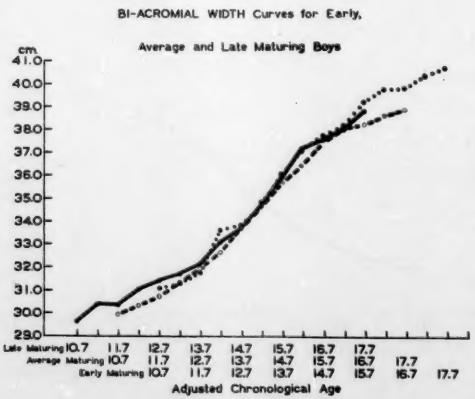
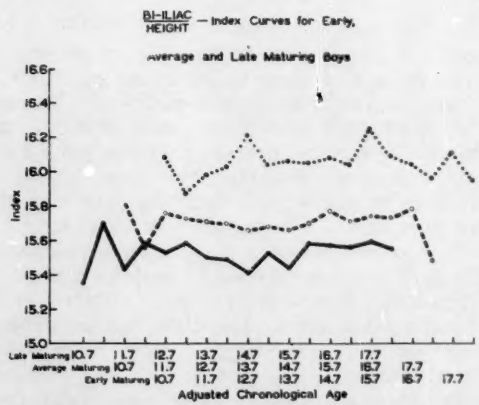


TABLE 6

MEANS AND STANDARD DEVIATIONS (S.D.) OF BOYS $\frac{\text{BI-ILIAC}}{\text{HEIGHT}}$ INDEX GROUPED ACCORDING TO AGE AT REACHING SKELETAL MATURITY

C.A.	Early-Maturing n	Mean	S.D.	Average-Maturing n	Mean	S.D.	Late-Maturing n	Mean	S.D.
10.7	7	16.1	.93	19	15.8	.88	12	15.4	.63
11.2	13	15.9	.42	24	15.6	.85	12	15.7	.44
11.7	19	16.0	.66	30	15.8	.71	18	15.4	.47
12.2	16	16.0	.56	33	15.7	.72	18	15.6	.48
12.7	20	16.2	.54	35	15.7	.74	20	15.5	.54
13.2	19	16.0	.60	34	15.7	.78	20	15.6	.45
13.7	21	16.1	.58	33	15.7	.69	21	15.5	.47
14.2	19	16.0	.60	32	15.7	.72	20	15.5	.43
14.7	20	16.1	.60	34	15.7	.71	21	15.4	.50
15.2	18	16.0	.67	34	15.7	.73	19	15.5	.49
15.7	16	16.2	.57	33	15.8	.70	21	15.4	.42
16.2	15	16.1	.54	31	15.7	.70	18	15.6	.54
16.7	16	16.0	.63	34	15.7	.72	20	15.6	.46
17.2	15	16.0	.58	29	15.7	.70	20	15.6	.50
17.7	14	16.1	.58	23	15.8	.66	19	15.6	.57

Figure 20



average rate. The one exception to this is the bi-iliac diameter. The early maturers remain characteristically broader-hipped than the others. Critical ratios are given in Table 7 between the average and early maturers when adjusted to equivalent skeletal ages. These critical ratios are higher at the later ages, being greater than two at five comparisons.

TABLE 7

CRITICAL RATIOS BETWEEN MEANS OF EARLY, AVERAGE, AND LATE-MATURING GROUPS OF BOYS WHEN ADJUSTED TO EQUIVALENT SKELETAL AGES

C.A.			Critical Ratios						
			Height	Bi-iliac	Stem Length / Height		Bi-iliac / Height		
Early	Average	Late	Av. vs. Late	Av. vs. Early	Early vs. Late	Av. vs. Late	Early vs. Av.	Early vs. Late	Av. vs. Late
	10.7	11.7	1.9			2.8			1.7
	11.2	12.2	2.0			3.5			0.1
10.7	11.7	12.7	2.0	1.7	4.3	3.7	0.9	1.5	1.3
11.2	12.2	13.2	2.2	0.7	3.4	3.5	0.8	1.9	0.9
11.7	12.7	13.7	2.2	0.9	4.6	3.3	1.4	2.6	1.3
12.2	13.2	14.2	1.7	1.7	2.8	3.0	1.7	3.2	1.3
12.7	13.7	14.7	1.4	1.6	4.0	2.7	3.2	4.9	1.5
13.2	14.2	15.2	1.6	1.7	2.0	2.2	1.9	2.8	0.9
13.7	14.7	15.7	1.9	2.1	2.4	2.8	2.3	4.0	1.4
14.2	15.2	16.2	2.2	2.5	1.8	2.3	1.9	2.5	0.7
14.7	15.7	16.7	1.5	1.9	3.1	2.6	1.7	3.0	1.2
15.2	16.2	17.2	1.2	1.9	3.0	2.6	1.6	2.5	0.9
15.7	16.7	17.7	1.6	2.8	2.8	3.0	2.7	3.4	0.8
16.2	17.2			3.2			1.9		
16.7	17.7			2.7			1.2		

As for indices of body build, the curves for the $\frac{\text{bi-iliac}}{\text{height}}$ index (adjusted for skeletal maturity - Figure 20 and Table 6) show the three groups of boys to be unlike each other. The differences found here between the early- and late-maturing groups are at most ages significant, with critical ratios for ages later than 11.5 years ranging between 2.5 and 4.9 (Table 7). In other words, the early-maturing boys are typically broad-built (as indicated by hip-width) while the late-maturing boys are generally slender-built in relation to their height, and all three maturity groups maintain their same relative status throughout the period of observation. It may be noticed in passing that the trends of these curves are very different from those of the girls for the same index. The girls become broad-hipped during adolescence, while the boys remain narrow-hipped in relation to their height.

The ratios between bi-iliac and biacromial diameters (Table 8 and Figure 21) again show the early-maturing boys with a comparatively large hip-shoulder ratio while the average- and late-maturing boys are alike in having broad shoulders relative to bi-iliac widths-- the relationship which is usually considered to be typically masculine. Sex differences in this index become marked for all groups after about 14 years of age, and in terms of directional growth trends the early-maturing boys are no more like the girls than are the other boys.

TABLE 8

MEANS AND STANDARD DEVIATIONS (S.D.) OF $\frac{\text{BI-ILIAC}}{\text{BIACROMIAL}}$ INDEX FOR GROUPS DIVIDED ON THE BASIS OF AGE AT REACHING SKELETAL MATURITY

BOYS

C.A.	Early-Maturing n	Mean	S.D.	Average-Maturing n	Mean	S.D.	Late-Maturing n	Mean	S.D.
10.7	7	76.9	2.0	19	75.7	4.4	12	74.0	4.3
11.2	13	76.1	2.5	24	73.8	4.4	12	74.7	2.2
11.7	19	76.1	2.8	30	75.1	3.1	18	74.0	3.2
12.2	16	74.7	2.6	33	74.9	3.4	18	74.0	2.6
12.7	20	76.1	2.5	35	74.8	3.7	20	74.2	3.3
13.2	19	76.0	3.0	34	74.8	3.1	20	74.8	2.9
13.7	21	75.3	2.9	33	74.3	2.8	21	74.8	3.4
14.2	19	75.0	2.8	32	74.3	3.6	20	74.6	3.8
14.7	20	74.0	2.3	34	73.8	3.4	21	74.6	4.4
15.2	17	74.0	2.0	34	73.5	3.3	19	74.5	4.2
15.7	17	73.4	2.5	33	72.8	3.2	21	73.7	3.8
16.2	15	72.7	2.3	31	72.2	3.0	18	73.4	4.5
16.7	16	72.3	2.8	34	72.2	3.2	20	73.0	4.1
17.2	15	71.9	2.7	29	71.6	2.9	20	72.7	4.1
17.7	14	71.8	2.5	23	71.3	2.9	19	71.5	3.2

Figure 21

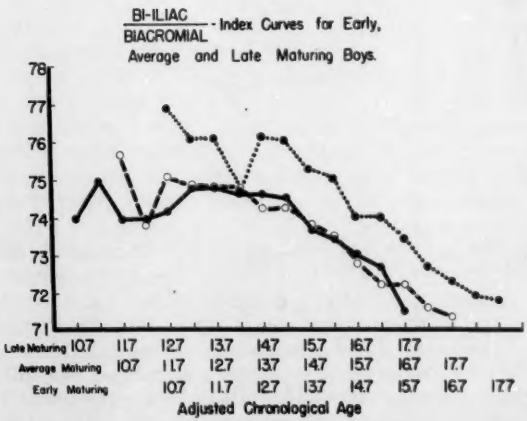

BI-ILIAC / BIACROMIAL - Index Curves for Early, Average and Late Maturing Boys.
78
77
76
75
74
73
72
71
Late Maturing 10.7 11.7 12.7 13.7 14.7 15.7 16.7 17.7
Average Maturing 10.7 11.7 12.7 13.7 14.7 15.7 16.7 17.7
Early Maturing 10.7 11.7 12.7 13.7 14.7 15.7 16.7 17.7
Adjusted Chronological Age

TABLE 9

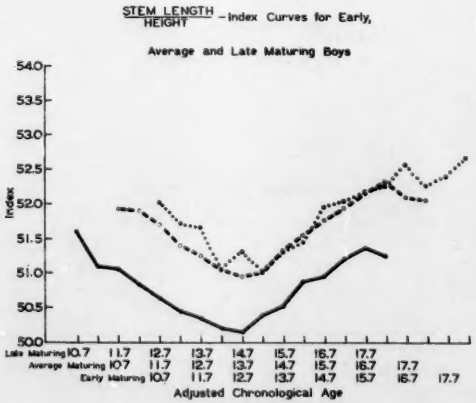
MEANS AND STANDARD DEVIATIONS (S.D.) OF $\frac{\text{STEM LENGTH}}{\text{HEIGHT}}$ INDEX FOR GROUPS DIVIDED ON THE BASIS OF AGE AT REACHING SKELETAL MATURITY

BOYS

C.A.	Early-Maturing n	Mean	S.D.	Average-Maturing n	Mean	S.D.	Late-Maturing n	Mean	S.D.
10.7	7	52.0	0.6	19	51.9	1.0	12	51.6	0.9
11.2	13	51.7	1.1	24	51.9	1.0	12	51.1	1.1
11.7	19	51.6	0.9	30	51.7	1.0	18	51.1	0.9
12.2	16	51.1	0.9	33	51.4	1.1	18	50.8	0.9
12.7	20	51.3	0.9	35	51.2	1.1	20	50.6	1.0
13.2	19	51.0	1.1	34	51.0	1.1	20	50.4	0.9
13.7	21	51.3	1.1	33	50.9	1.2	21	50.3	0.9
14.2	19	51.4	1.1	32	51.0	1.1	20	50.2	0.9
14.7	20	51.9	1.0	34	51.3	1.2	21	50.2	0.9
15.2	17	52.0	0.8	34	51.5	1.2	19	50.4	0.9
15.7	17	52.2	1.0	33	51.7	1.2	21	50.5	0.9
16.2	15	52.2	1.0	31	51.9	1.1	18	50.9	0.9
16.7	16	52.6	1.0	34	52.2	1.2	20	51.0	1.0
17.2	15	52.2	1.0	29	52.3	1.2	20	51.2	0.9
17.7	14	52.4	0.7	23	52.1	0.9	19	51.4	0.8

The $\frac{\text{stem length}}{\text{height}}$ indices of the boys (Table 9, Figure 22) bring out another significant difference in build. The late-

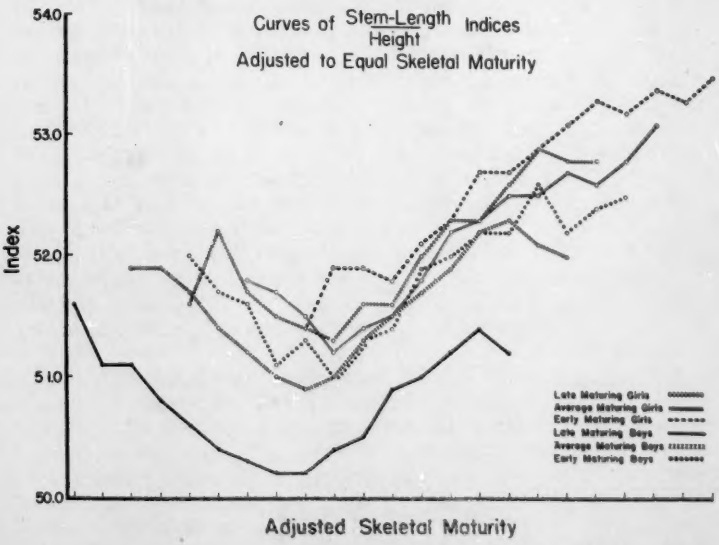
Figure 22



maturing boys are relatively long-legged - critical ratios range between 1.8 and 4.6 when the means are adjusted to equivalent skeletal age - while the early- and average-maturing boys are very like each other in this respect. Furthermore, if these curves are superimposed on the girls' curves, making adjustment to take care of the two-year difference in skeletal maturity (Figure 23), five of the six curves are seen to be practically identical, while the late-maturing boys stand out in a class by themselves. As we have seen earlier that they do not differ from the other boys in average stem length, this great difference appears to be primarily in the length of their legs. It would seem from this sample that the widespread belief that boys are relatively long-legged as compared with girls is due in large part to the influence of a small group of late-maturing boys.

It appears, then, that the late-maturing boy in this study is typically narrow-hipped and long-legged, and though small during his early teens, he tends to become tall or average in height as an adult, with average shoulder width. The early-maturing boy on the other hand is characteristically large and relatively broad-hipped at all ages.

Figure 23



INDIVIDUAL CASES

One of the principal advantages of a "longitudinal" study, such as the one in which the data for these findings were secured, is that we can trace the course of growth in an individual child as he develops. It is in order, then, to consider more specifically individual cases as they appear against the background of the group data. Numerous questions arise regarding the relations of the individuals to the total group and to the various sub-groups. Some of these questions are relevant to the material we have been working with. To what extent do the children in the group conform to the statistically differentiated "types" above described? When we examine the late-maturing boys, for example, how many of them can be described as average or tall in height, slender-built, long-legged? Furthermore, to what extent are our data influenced by the racial deviates who have been included? Do the South Europeans, who are reputed to mature early, show any similarity among themselves in rates of maturing and in body builds - and if so, to what extent does the inclusion of these cases influence the findings we have just presented?

First it may be well to consider, in the light of individual trends, the classification of early-, average-, and late-maturing cases which we have used. To what extent do these children remain in the same categories over the 3 1/2 year period for which we have x-ray data? We have already seen (Table 2) that the means of the groups remain well differentiated at earlier ages. Furthermore the r's for consistency of skeletal maturity ratings (3, Figure 1) remain fairly high even over the longest age interval (r is .80 between the ages of 14.2 and 17.2). But we can go farther, and follow the course of each individual to determine the extent to which he remains in his classification. In order to do this, growth curves of deviations from the Todd norms, expressed in years and tenths, were plotted against C. A. for each case. From inspection of these curves it was clear that in most instances the children did not vary from the original classifications, which had been based on terminal status. Some children shifted in their relative status, and in a few instances these shifts crossed boundaries from one category to the next.

The cases whose shifts might have changed them from the original classification were counted, with the following results. Among the late-maturing boys, as originally classified, there are 3 who at most ages appear to be about average in skeletal maturity. One boy who was originally classed as average is seen by his deviation curve to be slow-maturing at most ages. At the other end of the scale, 4 of the average-maturing boys were at earlier ages somewhat advanced for their ages. One

boy who had been classed as early-maturing was at most ages only slightly advanced, and perhaps should have been called average. Of the 77 boys, 7, or at the most 9, would fall in different categories at the earlier ages considered in the study; from 68 to 70 (88 to 91 per cent) would remain in the same maturity classifications throughout.

Among the late-maturing girls, 3 were actually somewhat accelerated in their first x-rays, but slow rates of maturing toward the end of their growth brought them at the last into the retarded group. Two girls who had been classed as average appear, by their deviation curves, to be at most ages somewhat retarded, but they are borderline cases and might be classed either way. Among the early-maturing group of girls there are none who were average at most ages, though two cases were so at their first x-rays and then accelerated rapidly. Four who had been classed as average were advanced at earlier ages, slowing down as they approached maturity. Again for the girls, 7 or possibly 11, would be in different categories at the earlier ages; leaving at least 84 per cent and probably 90 per cent in the same classification at all ages.

To summarize, classification based on earlier ages than those used would have changed a few cases but, as is apparent from Table 2, would have made little difference in the statistical findings. We see, however, that some children's rates of skeletal maturing are not consistent with the total group, and we may expect their rates of growth in other physical aspects to fluctuate in a similar manner. Hence we shall note whether children who do not consistently fit into our original skeletal age categories are deviates from the groups in other ways as well.

a. Racial Deviates

It has already been indicated in the preceding article (3) that the children in this study can, for the most part, be classified in a loose and general category which is composed of "Old Americans" (largely of North European ancestry) and more recently immigrated North Europeans (for the most part first generation in the United States). This is not a very homogeneous group, but is characteristic of many white populations in the United States. As noted in the description of this sample, a few of the children are of sufficiently different racial origin that it has seemed wise to examine the extent to which they differ from the main group before we include them unqualifiedly in our classifications.

Of the 11 boys who do not fit into the general North European-American group, 4 are Italians. Their ages at reaching a skeletal age of 17.25 years are: 15.1, 17.0, 17.7, and one who

was not yet mature when data collection was discontinued, but was a year retarded at that time. These boys are spread throughout the range of maturing, with only one early-maturing. The Armenian and the Hungarian matured about 6 months early, the half-Jewish boy at average age. Of two who were part Spanish, one matured about 8 months early, the other 6 months late, the Mexican matured almost 2 years early, and the part Tahitian a full 4 years early. The average age of attaining Sk. A. 17.2 for the 10 boys who attained it, is 16.6 years, somewhat earlier than the average, which is 17.01 years for the total group (S. D. [illegible]). They are distributed: 4 in the early-, 4 in the average-, and 2 in the late-maturing group. They comprise a little less than one-fifth of the early-maturing group, about one-ninth of the average, and one-tenth of the late-maturing group. If their physical builds are racially distinct from those characteristic of the larger group their preponderance in this early-maturing group might have some influence on the differences we have found between early- and late-maturing boys.

The anthropometric data for all of the children in the study have been converted into standard scores[3] for each (6-month) C. A. interval. Using these scores, individual curves of relative size in nine measures and two indices ($\frac{\text{bi-iliac}}{\text{height}}$ and $\frac{\text{weight}}{\text{height}}$) had been plotted against age. In order to determine a child's relative size and build, all of his anthropometric curves were spread out and a short descriptive picture was made from them. Using these descriptions we may characterize the boys in the racially deviate group as follows: in terms of their adult status, none of these 10 boys is tall, 5 are average, 5 short; 6 are described as of wide or stocky build, 2 average and 2 slender. "Short and stocky" is the most frequent description (four cases). However, of the 4 who matured early only 2 are short, while 3 are broad-built and one rather narrow-hipped. These descriptions do not indicate any very impressive weighting of any of the three maturity groups which could be ascribed to racial differences, though the 2 late-maturing boys are short and stocky and not like the other late-maturing boys.

The 12 racially deviate girls present a somewhat similar picture. They are more often short (eight cases) and broad-built (seven cases) but not exclusively so. Only one, who is Jewish, is late-maturing and she is generally small - unlike the

[3] *These standard scores, or T-scores, were obtained by subtracting the individual's measure from the mean for that age and dividing this difference by the standard deviation for that age. In order to make all scores positive these S.D. scores were multiplied by 10 and then converted into a numerical series in which 50 represents the group mean.*

trends of late-maturing girls. Of the 5 early-maturing girls, 2 are short and stocky, one is tall and broad, one tall and average in build, while one (the Jewish-Roumanian-Russian) is average in height but with narrow hips. There is not, among these girls, any similarity in build that would alter, because of racial factors, the tendencies found for the total group of early-maturing girls. Although there is a greater frequency of both early-maturing and short, stocky builds, the two do not invariably go together. When compared (by inspection) with curves of the 20 other early-maturing girls they do not stand out as in any way characteristically different.

Means and standard deviations for the different groups, excluding the non-Nordic cases, are shown for three ages in Table 10. When these means are compared with those in Tables 1, 4, 5, 6, and 8, we see that for the most part the relationships remain the same, though the figures shift. The boys' data show that in height both extreme groups tend to be taller, but especially the late-maturing; both extreme groups tend to be slenderer-hipped in relation to height and to be a little longer-legged; that is, the elimination of the short, stocky non-Nordics changes the means of both extreme groups in the direction of taller and slenderer, but maintains the differences between the early- and late-maturing groups.

As for the girls, the elimination of the non-Nordics makes all groups very slightly taller, tends to emphasize the difference in biacromial width of the two extreme groups at 15.7 years, and has no effect on the means of the $\frac{\text{bi-iliac}}{\text{height}}$ index.

In this connection Shuttleworth's findings for a group of 33 Italian girls as compared with 193 North European girls, all from the Harvard Growth Study, are pertinent. He found a normal distribution of menarcheal age in both groups. In anthropometric dimensions "the North Europeans are consistently taller and... the differences in stature are due largely to differences in leg length. Differences in average sitting height, bi-iliac diameter, and weight are negligible. Considering the small number of Italians, the patterns generated by the annual increments of the two groups could hardly be more alike. The only consistent difference is that the pattern of growth in leg length among Italians is less intense" (6, p. 150). As our racially deviate cases are primarily Italian, these findings of Shuttleworth on Italians tend to corroborate our own data. In general, we seem to be justified in including all of the cases in our statistical treatment. On the other hand, the cases which do not fit into our general descriptive classifications are more likely to be from the short, stocky non-North European group.

TABLE 10

ANTHROPOMETRIC DATA FOR EARLY, AVERAGE, AND LATE-MATURING GROUPS, INCLUDING ONLY CASES OF OLD AMERICAN AND NORTH EUROPEAN STOCK

	Early-Maturing			Average-Maturing			Late-Maturing		
C.A.	n	Mean	S.D.	n	Mean	S.D.	n	Mean	S.D.
BOYS									
Height									
11.7	16	1519	72	26	1465	64	16	1463	36
13.7	17	1693	87	30	1597	73	19	1563	45
15.7	15	1783	81	29	1733	68	19	1721	51
Biacromial									
11.7	16	316	14	26	307	12	16	305	18
13.7	17	360	20	30	336	17	19	322	21
15.7	14	391	22	29	374	15	19	360	22
Bi-iliac / Height Index									
11.7	16	15.9	.64	26	15.8	.72	16	15.4	.48
13.7	17	16.0	.54	30	15.7	.70	19	15.4	.47
15.7	14	16.2	.59	29	15.8	.70	19	15.4	.40
Stem Length / Height Index									
11.7	16	51.5	0.9	26	51.6	1.0	16	51.0	0.9
13.7	17	51.0	1.1	30	51.0	1.2	19	50.2	0.9
15.7	15	52.0	0.8	29	51.7	1.2	19	50.4	1.0
GIRLS									
Height									
11.7	20	1518	57	19	1475	60	17	1441	82
13.7	19	1596	44	21	1596	53	19	1581	75
15.7	19	1619	45	17	1632	59	17	1639	57
Biacromial									
11.7	20	325	16	19	314	14	17	316	18
13.7	19	342	14	21	339	14	19	342	21
15.7	19	350	17	17	352	10	17	359	17
Bi-iliac / Height Index									
11.7	20	16.4	.77	19	16.4	.77	17	16.4	.61
13.7	19	16.7	.78	21	16.5	.88	19	16.4	.61
15.7	19	17.2	.88	17	17.2	.70	17	16.8	.66

b. Individual Builds in Relation to Rate of Maturing: Boys

To return to our question about differences in build which may be related to rates of maturing, let us inspect the growth curves of children from the extreme groups. Inspection of the boys' T-score growth curves give the impression that early-maturing boys characteristically have spurts of rapid growth, after which they slow down and to some extent approach the average; they are wide-hipped, and seldom below average in height. Sample curves for height are shown in Figure 24 for the 7 earliest-maturing boys. The early-maturing South European

boys in this extreme group (F 13, F 5, E 10) tend to show the same growth rates and builds as the others, but they are only average or short in height as adults. If they were eliminated the early-maturing boys would stand out still more clearly as a tall group. Among the 21 early-maturing boys, only one curve fails to show a spurt of relatively rapid growth in height during the early years of the study, with a later period of slow growth (though in some cases the trends are very slight). The one exception (not shown) remains tall, and equally so, throughout. However, his curve of skeletal acceleration is almost concave in appearance, and from 14.5 through 16 years he was accelerated less than 6 months, and would have been considered average in skeletal development at those ages. Twelve of the 21 boys in this classification are relatively tall at all ages. Only 3 are below average height at all ages; 3 more drop slightly below the T-score of 50 at their final measure. Twelve of the boys have broad bi-iliac diameters relative to their own height; 4 are average in this respect, 3 slightly narrow-hipped, and 2 tall boys have relatively very narrow bi-iliacs. Of the 7 earliest maturing all have above-average $\frac{\text{bi-iliac}}{\text{height}}$ indices at most ages.

In general, as was to be expected, the individual growth curves show that most of the early-maturing boys fit the descriptions found for them when their measures were averaged; that is, most of them are consistently tall and broad-hipped.

In terms of the group means the late-maturing boys are long-legged and narrow-hipped. Inspection of individual curves shows that 8 of the 21 fit this description completely. Furthermore, of the 7 who reached a Sk. A. of 17.2 at 18.0 or later, 5 are in this group (Figure 25). Six boys are relatively narrow-hipped but not long-legged; though only one of them has a longer than average truck length for his total height. Five are relatively long-legged but not narrow-hipped; two of them being definitely broad-hipped. Two boys do not fit our general description in either respect. They are both short and broad-built, one of them being definitely short-legged. Both of these boys are of South European ancestry; although neither was extremely late-maturing (17.7 and 17.8 years), they were consistently rather slow-maturing and were both about a year retarded at 14 years of age when first x-rayed.

Silhouettes of a typical early and a typical late-maturing boy are shown at two ages in Figure 26. Note that at 13 years the late maturer is much the shorter of the two relative to his 17-year height. At the 17-year pictures the late maturer is a full year retarded in skeletal age; he does not reach the Sk. A. of 17.2 until he is 18.2 years old. On the other hand, the early maturer is already completely mature at 17 years; he attained

Figure 24

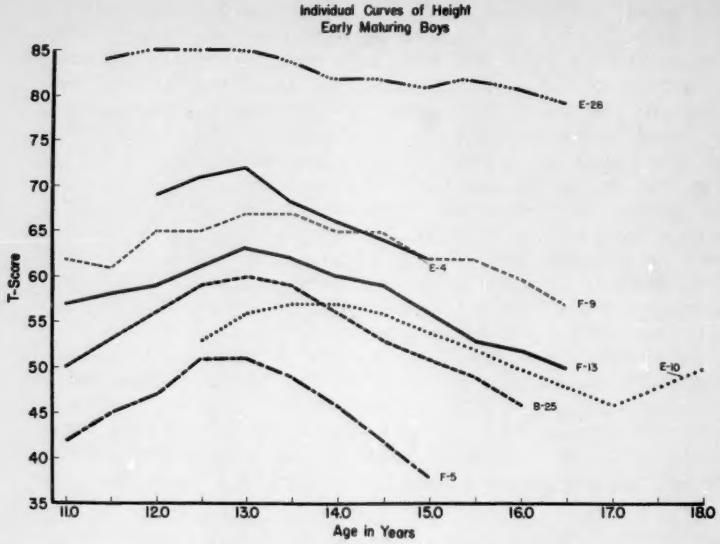


Figure 25

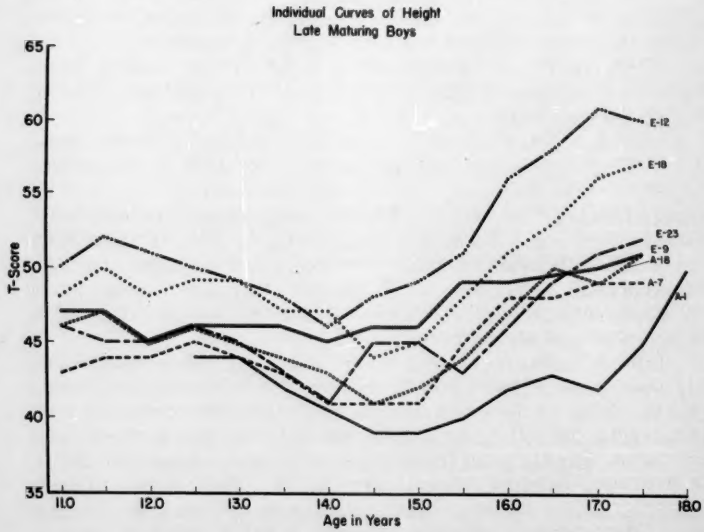
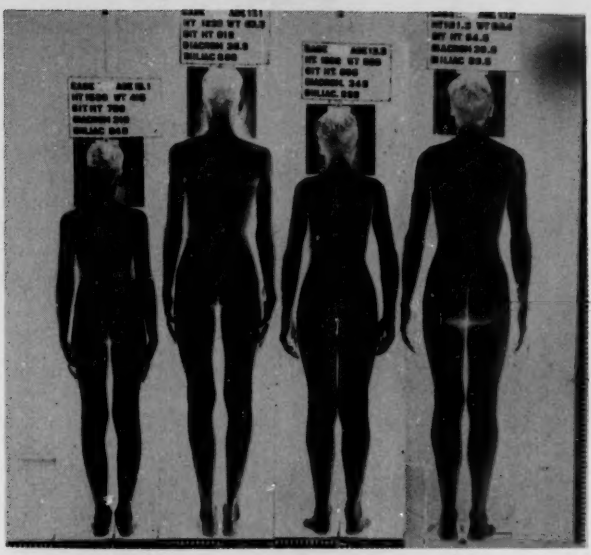


Figure 26



Sk. A. 17.25 at C. A. 15.7. The characteristic differences of build are evidenced in these silhouettes - the long-legged, slender build of the late maturer, and the short-legged, wide-hipped and generally heavier build of the early maturer.

Some typical "word-pictures" of the late-maturing boys, made from the inspection of their growth curves may serve as further illustrations.

Case A 1, Sk. A. 17.2 at C. A. 18.8. Height: short until 18.2 when he is average. Weight: light, parallels height T-score curve. Bi-iliac: narrow. Chest depth: very shallow. Chest breadth: narrow. Biacromial: very narrow. Bitrochanter: narrow. Stem length: short. Sitting height: also short. Chest circumference: small. Circumferences of thigh, leg, arm and neck: all small, approaching average at 18.2, the thigh measure attaining average. General picture of a slender-built, long-legged boy.

Case A 7, Sk. A. 17.2 at 18.3. Height: rather short but approaches and almost attains average at 17.0 and 17.5 years. Weight: light, approaches near to average with increasing age. Stem length and Sitting Height: short, tends toward average at later ages. Bi-iliac and biacromial: both narrow but approaching average, latter achieving average by 15.5 years. Chest Circumference: narrow, approaches average with increasing age. Chest depth: average, becoming thick after 14 years.

Chest breadth: very narrow, becoming more so. Circumferences of thigh, leg, arm and neck: start small, become average about 16 years, more or less. Generally small size until near maturity. Becomes adult of almost average height with a tendency toward slender build, but broad shoulders.

Case E 23, Sk. A. 17.2 at 18.1. Height: short early, above average after 16.5 years. Weight: light at all ages. Bi-iliac: very narrow. Biacromial and Bitrochanter: about average for height, though shoulders remain narrow at later ages when height increases. Sitting height and Stem length: average for height. Chest diameters: a little large for height. Circumferences: average for height. He is small at first, becomes average in height as an adult, is on the slender side, with very narrow bi-iliac and narrow shoulders.

c. Individual Builds in Relation to Rate of Maturing: Girls

The means for the early-, average-, and late-maturing girls do not show very marked differentiations in build, so we may expect to find few differences between the mature builds of the individual children in the two extreme groups.

Of the 28 late-maturing girls (19 in the statistical group and 9 who did not complete maturity within the period of measurement), all but 3 show increasing T-scores for height with advancing age. (Figure 27 shows the 7 latest maturing.) The T-curves of 2 of these 3 can be explained by an examination of their earlier records. One was actually accelerated before 16 years of age (her height curve reflects this) and the second was only about 3 months retarded before 16 years of age. On the other hand, we have no explanation for the third who was retarded about 9 months at all ages. If we describe build in terms of the $\frac{\text{bi-iliac}}{\text{height}}$ index, we find that 16 become increasingly broad-hipped at the later ages, ten of them exhibiting a flattened U-shaped curve, i.e., higher T-scores in this index in both the earlier and the later ages measured. Apparently these girls were relatively narrow-hipped for a few years because they were slow in maturing. Seven girls showed no directional trends in this index, while 5 have steadily dropping curves. Even though the expected trends occur in most cases, they do not always do so. Four of these 5 non-conformists have below-average indices at all ages - i.e., are slender-built, and are apparently cases who do not have marked growth spurts in hip-width. Of the 19 girls in this group who had reached mature status their curves show 8 tall, 6 average, and 5 short; with a symmetrical distribution of builds ($\frac{\text{bi-iliac}}{\text{height}}$ index) 5 wide, 10 average, and 4 slender. If we add the 9 whose

growth is incomplete the tendency to be tall is still evident (11 tall, 10 average, 7 short) but there appears also to be a tendency toward slenderness (6 wide, 12 average, and 10 narrow); this latter tendency, however, appears to be only a matter of incomplete growth. There are 4 girls among the 28 who are short and stocky in build. Two others are both short and narrow-hipped.

Twenty of the 25 early-maturing girls have height curves which show a consistent decrease in T-scores with advancing age (Figure 28 shows the 7 earliest maturing) - in accord with the trend of the mean for this group. The 5 who do not, maintain fairly stable positions near the average with the exception of one consistently tall girl. The skeletal deviation curves for these 5 show that they are not among the extreme deviates in bone maturity; two were only average in the first x-rays and the other 3 were never as much as a full year advanced. As for the mature height and build of the early-maturing girls, the curves show 7 to be tall, 10 average, and 8 short, with 9 broad-hipped, 7 average and 9 narrow or slender-hipped (bi-iliac diameter). These frequencies do not show any strong trends toward extremes in either size or build. There is, however, among the individuals of the group a marked shift in relative status from large to small as they grow older.

It is evident from these summaries of cases that body build in girls is not (as it is in the boys) related to rates of skeletal maturing. The only relationship we find is a moderate one between rate of maturing and size; early maturers are relatively large from 10 to 12 or 13 years because of their early period of rapid growth; but they are small as adults, while late-maturing girls are more often just the reverse.

SUMMARIZATION OF SEX DIFFERENCES AND SIMILARITIES

In terms of average rates of skeletal maturing there are, as we have seen, about 2 years difference between the sexes in the age at reaching bone maturity (complete closure of the epiphyses of hand and knee). Our sub divisions within each sex have separated the children into 6 groups, which reach maturity successively, approximately one year apart, except for the early-maturing boys and the late-maturing girls whose age at epiphyseal closure is about the same. Furthermore, there is an overlap of 3 years (15.0 to 17.9) in the ages at which both boys and girls are reaching skeletal maturity. The question arises: are there differences in growth and build which show characteristic shifts in a masculinity-femininity series in agreement with shifts in age at maturing, or are the sex differences independent of this variable? The answers to this question are scattered throughout this and the companion paper,

Figure 27

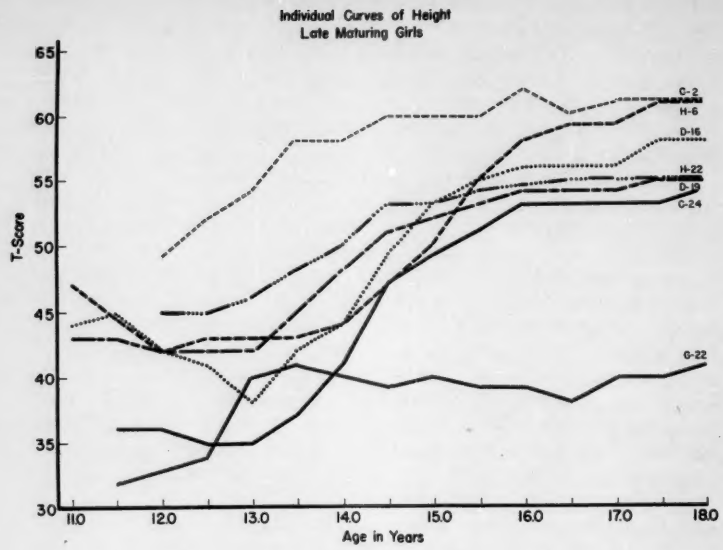
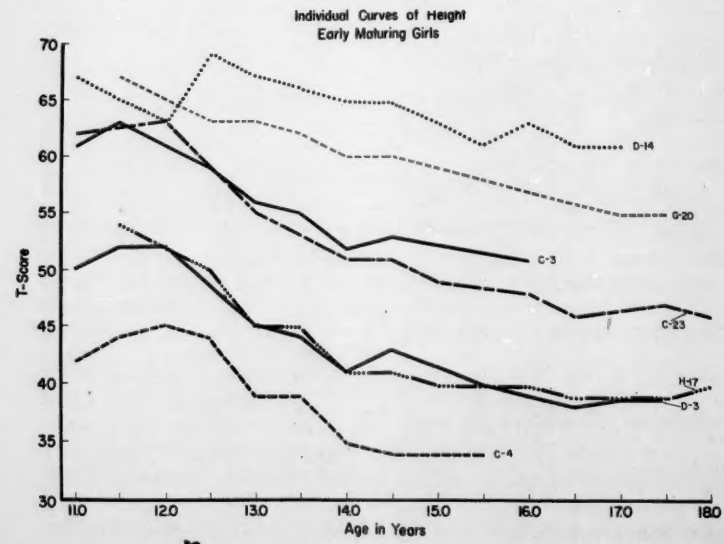


Figure 28



but it will be of interest to review them here with this question in mind.

The children in this study exhibit normal trends of growth in size as may be seen in the curves of the means for height, stem length, bi-iliac and biacromial diameters for the total groups (3, Figures 31, 32, 33, and 34). Furthermore, the sexes differ in their growth trends for each of these dimensions. We find that, as in other anthropometric studies, between 11 and 14 years of age, the girls average larger in all dimensions. But the boys overtake them, first in height at 13.5 years, then in stem length and biacromial diameter at 14 years. The girls maintain a slightly broader bi-iliac dimension, although by 16 years the means are practically identical.

When we consider early-, average-, and late-maturing groups, comparison of the growth curves in size shows that, regardless of rate of maturing the growth curves for the two sexes remain distinctive in their trends after the adolescent growth spurt starts. There is, for example, no tendency for the growth curves of the early-maturing boys to look more like those of the late-maturing girls, as compared with the average curves for each sex. There are, furthermore, additional sex differences in the relations between early and late-maturing groups:

(a) Height curves show reversal of the positions of the early- and late-maturing girls but no such reversal occurs among the boys (Figures 1 and 12).

(b) Among the maturity groups comparisons of the bi-iliac growth curves, adjusted to skeletal equivalence, reveal diverse trends, with the early-maturing boys and the late-maturing girls having the wider bi-iliac diameters (Figures 7 and 18).

(c) Biacromial width shows differences between maturity groups in the girls but not in the boys (Figures 8 and 19).

(d) The most striking sex differences are seen in the $\frac{\text{bi-iliac}}{\text{height}}$ index curves (Figures 9 and 20). The boys show no directional shift with age, but maintain significant differences between maturity groups, the early-maturing boys being relatively broad, and the late-maturing boys narrow-hipped. The girls, on the other hand, have $\frac{\text{bi-iliac}}{\text{height}}$ indices which rise rapidly for all groups alike after a skeletal age of 12.2. What is more, they are not differentiated in relative hip-width when compared for maturity groups.

(e) The greatest directional difference with increasing age is found in the $\frac{\text{bi-iliac}}{\text{biacromial}}$ index (Figures 11 and 21). The indices for the sexes are similar at first, but at a boy's Sk. A. of about 14.5 years they start to diverge; after this, the girls' indices increase and the boys' indices decrease, i.e., the boys become

broad-shouldered and the girls broad-hipped. Here again the trends are characteristic of the sexes regardless of the age at which they start, though the actual differences are least between late-maturing girls and early-maturing boys.

(f) The $\frac{\text{stem length}}{\text{height}}$ index is the only one which has a similar trend for the two sexes (Figure 23). In fact, as we have already pointed out, the curves for five of the six maturity groups, when adjusted for skeletal equivalence, are almost superimposed, though the girls' curves tend to be very slightly higher; while the sixth group - the late-maturing boys - though still showing the same trends, have consistently lower indices (i.e., have shorter bodies and longer legs for their total height).

The foregoing résumé shows that in the matter of growth trends in absolute size and body build during adolescence, the sexes are for the most part distinct in their characteristics and are by no means extremes, or even a bi-modal distribution, on the same continuum. This is true so long as we use rate of growth changes as a basis for comparing the sexes.

However, when we compare the percentage curves the picture is different (3, Figures 35 and 36). When per cent of mature height and stem length are plotted against age, sex differences seem to be eliminated once the groups are equated for skeletal maturity. There appears to be a relation between the maturity of the skeleton and the proportion of completed growth, which is independent of sex.

In view of the sex differences found, it is of interest that the boys selected by the physician as most sex-inappropriate at some time during their growth do not follow these tendencies. None of these 6 boys is early-maturing - in fact, 3 of them fall into the late-maturing class. Their deviations are not at all in the "feminine" direction insofar as rates of maturing are concerned. They appear, instead, to be a-typical (perhaps a-sexual?) for a period during their growth.

SUMMARY AND CONCLUSIONS

Within a group of adolescent children (90 boys and 87 girls) close relationships were found between the process of skeletal maturing and growth in size. The members of each sex were subdivided into early-, average-, and late-maturing groups (three groups for each sex) on the basis of age at reaching a given skeletal age. In the girls the division was made according to chronological age at attaining a skeletal age of 16.25, or complete closure of epiphyses of the hand and knee. The boys, who mature on the average two years later than girls, were divided according to age at attaining the skeletal age of 17.25 years, or about one year before complete epiphyseal

closure. In this study skeletal development has been the sole criterion for determining rates of maturing. On the basis of this criterion a number of differences in anthropometric dimensions were found to characterize groups who matured at different rates.

Early-maturing girls, as a group, are relatively large and the late-maturing girls are small before 13 years; while after this age their relative sizes are reversed. For their skeletal ages the late-maturing girls tend to be larger than average at all ages. There is also a consistent tendency for the early-maturing girls to be small for their skeletal ages.

Comparisons of the several groups of girls with reference to their body build, as measured in the $\frac{\text{bi-iliac}}{\text{height}}$, $\frac{\text{stem length}}{\text{height}}$, and $\frac{\text{bi-iliac}}{\text{biacromial}}$ indices revealed very little difference in build which could be related to their rates of maturing. Although the early-maturing girls are relatively broad-hipped and the late maturers narrow-hipped when compared at a given chronological age, the differences disappear if the comparison is made between girls of similar skeletal ages. The one difference which is consistent, whether determined on the basis of C. A. or Sk. A., is the $\frac{\text{bi-iliac}}{\text{biacromial}}$ index: the late-maturing girls tend to be broad-shouldered, especially when compared with the early-maturing girls.

Among the boys, the relations between the rate of maturing and growth in size are rather different from those found among the girls. For their chronological age early-maturing boys are relatively large at all ages; late-maturing boys are small between the ages of 11 and 16. When compared at the same skeletal ages, these differences disappear, with one exception - early-maturing boys have relatively broad hips at all ages, especially as they grow older. The indices of build show the late maturers to be characteristically slender-hipped and long-legged, while the early maturers are typically broad-hipped.

The differences found do not appear to be due to racial or national characteristics. Although the small number of Italians and other South Europeans in the study tend to be short and broad-built, they were not consistently so, and were found in all maturity groups. Elimination of these cases did not alter the relationships found between groups maturing at different rates.

Descriptions of the cases who were most deviate in rate of maturing, corroborate the statistical differences found for the larger groups.

It is to be concluded from the summarization of sex differences that we cannot say that early-maturing boys are characteristically more feminine, or late-maturing girls more masculine in their directional trends of growth. It is true, however, that in some characteristics the deviations are in this

direction: early-maturing boys tend to have broad hips and narrow shoulders (which is nearer to the girls' norms) while late-maturing girls tend to be larger and to have broader shoulders (that is, nearer to the boys' norms in these characteristics). Late-maturing boys, on the other hand, are most deviate of all the groups and would, all in all, contrast most markedly with the early-maturing girls.

There is one type of comparison, however, in which sex differences practically disappear. If we control the degree of skeletal maturity, by adjusting for the two-year sex difference in bone maturity during these adolescent years, then the growth curves for per cent of mature height are closely similar for the two sexes. The same is true for per cent of mature stem length. This may be another indication that growth in size is closely related to the processes of maturation of the skeleton. Eventual size may be primarily determined by such factors as sex and other innate characteristics, with a child's progress toward that mature size (proportionate growth) occurring at the same rate that his skeleton matures. If this is true, then roentgenograms of a child's hand and knee should serve as excellent indicators of the proportion of his growth which he has completed at any given time.

The results of these studies have several interesting implications for possible relationships to other characteristics of adolescent development. It is planned to present, in later publications, data on relationships of rates of maturing and body build to such factors as strength, skill in motor abilities, and social and emotional adjustments. Preliminary studies (2, 4) have shown that when children are classified according to the age at which they reach skeletal maturity, there are significant differences among boys in strength and motor abilities as well as in size and build. There is a further indication that deviations in rates of maturing are also accompanied by some differences in personality characteristics which seem to be in part related to the stage of maturity, and in part a reaction to social acceptance and status as it is affected by their physical deviations.

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AFFECTIVITY AND GROWTH IN CHILDREN[1]

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INTRODUCTION

The affective or feeling side of personality is playing a role of increasing importance in current research in child development. Whenever one wants to know how children learn, why they behave as they do, or even to fully appreciate their states of health, he must sooner or later find out how they "feel" about the situation.

The importance attributed to affectivity or feeling states in general psychological literature is apparent throughout the history of psychology. The general historical trend seems to have been in the direction of gradually establishing a closer connection between mental and physical functions. Affectivity has been conceived as related to mental and physical processes in varied and contrasting ways. As psychologists join and relate the mental and the physical, affective areas must then be investigated in terms of both.

The present study of the affective area of personality adds another approach to the problem attempted by the University of Michigan growth studies, that of describing the "whole" child through time. Olson and other members of the University Elementary School staff have been engaged for the past decade in collecting continuous growth records of the children enrolled in the preschool and elementary grades. The general point of view of the growth studies has been that the unique problem of research in child development is to see what the child as a whole is like now, what he was, and what he may be later. When an individual child is chosen for special study he is less often compared with others and more often studied by comparing his present status with his own previous status. The University of Michigan growth studies have emphasized consecutive measures of height, weight, dentition, wrist bone development, educational achievement, mentality, strength of grip, and maturity of inter-

[1] *The writer was, at the time of the study, a member of the staff of the University of Michigan Elementary School and collected these data as a companion document to the Growth Studies still in progress there under the direction of Dr. Willard C. Olson.*

ests. In order to portray growth data collected in many types of units in an understandable manner all measurements have been translated into age units, such as height age, weight age, and dental age. Thus, all objective data can conveniently be plotted on a single graphic growth record. When a generalization is needed concerning a child's status at a given time all of the above-mentioned measures are averaged and the composite age thus derived is designated "organismic age."

When considering the above measures from the "whole" child point of view it is evident that personality and social areas are not represented to any appreciable degree. Several attempts have been made previously to sample these areas and to relate them to total growth patterns. Studies on the personality and social areas include measures of social age, handwriting, seeking tendencies, and interests. Conclusions suggested by all of these investigations place personal and social factors within the totality in much the same way as physical and mental items relate to each other.

A measure of affectivity has thus been sought, to be subsequently related to growth patterns which already include various measures of physical and mental functions.

A PLAN FOR THE STUDY OF AFFECTIVITY

A survey of methods most commonly used to investigate personality revealed frequent use of standardized tests and rating scales, questionnaires, systematic observation, physiological measurements, case studies, psychoanálysis, and projective techniques. None of the existing tests or scales seemed adequate to sample affectivity in children, because it was felt that the sample should be obtained from the children directly to avoid some of the errors of judgment and interpretation. Furthermore, the prospective subjects for the study were young children for whom complete growth data were available and who would be unable to read test material. Existing questionnaires were likewise too difficult to be used by the children, and, in addition, they usually were directed toward sampling more specific traits than was sought in the more general concept of affectivity. Observational methods were discarded as too complex to lend themselves to the general description. Physiological studies of personality require the use of technical laboratory equipment which was not available. The case study method offered possibilities for describing individual children but did not lend itself to statistical analysis so that interrelationships between affective factors and other measures could be determined. Psychoanalysis requires the services of a skilled analyst and could not be conducted adequately by the worker trained in other frames of reference. Projection (the act of

externalizing, or of perceiving an object as spatially and sensibly objective) assumes a certain amount of transfer from an abstract idea to a concrete object and interpretation is often difficult.

In order to study affectivity or feeling states in children it was believed that the children would have to project their feelings in some way onto material which was understandable and meaningful to them. Abstractions and general affectivity terms would not be expected to have meaning for children. Consequently, it was decided to borrow a method commonly used to obtain data for case studies and psychoanalysis, that of the personal interview, and to consider the responses to the interview as verbal projection structured only within the limits of the questions asked. In this way affectivity could be studied without the limitations of equipment, personnel, inability of the subjects to read or write, or the specificity of traits obtained in many experimental procedures. The assumption must be made, however, that the answers to interview questions actually measure affectivity.

Once the material concerning affectivity in children is obtained from the personal interviews it can be related to all other information comprising the growth records of the children involved. Since repeated measures had been made for all other samples of growth, it was decided to interview the children at least twice in order to study the relationship of affectivity to the composite growth status at a given time and also to the direction of change which growth patterns were taking during the time when the study was in progress.

Since the purpose of the investigation was to sample the affective side of the child's personality, interview questions were selected with that purpose in mind. Three sources were tapped in order to obtain statements or questions descriptive of personality

1. Standardized personality tests and rating scales.
2. Publications reporting clinical aspects of personality study.
3. Textbook discussions of personality.

Items which became familiar with repeated inclusion in different survey sources were recorded and restated in simple interrogative terms as closely resembling the original items as possible. A minimum of five appearances in surveyed material was necessary for inclusion of the statement in the experimental interview questionnaire.

Seventy-five questions were obtained by the method described above. An initial series of interviews was scheduled to perfect the interview blank and technique and also to discover suggestions for subsequent treatment of results. The children were scheduled individually and the interviews took place in a private office with which the children were familiar.

No one was present except the interviewer and interviewee. All questions were asked orally and the interviewer recorded the subject's responses as inconspicuously as possible. Several minor revisions of questions, elimination of four ambiguous or confusing questions, and minor refinements of the interviewing technique resulted from the initial series of interviews. The final revised interview blank thus contained 71 questions.

SCORING METHOD

In order to obtain a statistical analysis of the interview material, the revised interview blanks were administered to several adult groups trained in child development. These 150 adults were instructed to write in the preferred response to each question, "preferred" meaning a response which would seem to indicate a positive state of affectivity, happiness, or contentment. Collective judgments of the adult groups were used to allot one score point to every preferred response recorded so that a high numerical score would indicate a high level of affectivity and a low numerical score a low level of affectivity. Since several of the 71 interview questions contained more than one part, and one score point was allotted for each preferred response the highest obtainable total score for the revised interview became 81. A sample revised and scored form of the interview blank appears on pages 95-101

DESCRIPTION OF SUBJECTS

The experimental group for the first series of interviews was composed of 30 boys and 35 girls ranging from 86 months to 149 months in chronological age and from 90 months to 210 months in mental age. They were all regularly enrolled pupils in the second, third, fourth, fifth, and sixth grades of the University Elementary School. After the graduation of the sixth grade group in the first series, there remained 44 children for the second series the following year. The second series of interviews, then, was administered to 20 girls and 24 boys ranging from 96 months to 144 months in chronological age and from 97 months to 206 months in mental age.

DISTRIBUTION, RELIABILITY, AND VALIDITY OF AFFECTIVITY SCORES

Scoring of the interview blanks revealed the range of affectivity on the first series of interviews was from 35 to 70, with a mean score of 55.0 and a standard deviation of 7.9; on the second series the range was from 39 to 74 with a mean score of 54.7 and a standard deviation of 8.0. Therefore, it

Personal Report Blank (Mechem)

Name William Jones (42) Date 1-24-40

Age 120 mos. Sex M. Grade 5

1. How are you getting along this year? Half O.K. Same as last year.

2. Are there any new children in your room this year? Like new ones. There's a beautiful voice on Mary, the new girl. I just sit and listen to her.
Do you like to have new children there or would you rather the same ones would stay every year?

3. Which part of your work do you like the best? Science, singing, art, arithmetic.

4. Are you working with someone or mostly by yourself? By myself
Would you rather be alone a lot? No

5. Is your school work easy for you? No. I can't read.
Does it bother you much if you cannot do something that you are trying to do? Yes, I feel I'm dumb.

6. Are you shy? No, but I blush and get mad when girls kiss me.

7. Are your teachers usually nice to you? Yes

8. Do your teachers talk to you more than they do to other children in the room? Yes
Would you rather they talked to you less? No.
Why?

9. Do you always tell the truth? No. When I get in trouble, I lie out of it.

2 10. Do you get along all right with the other boys and girls in your room? Yes
Do they seem to fight you more than they do other children? No

11. Are you as large as other children your age? No.
Do you wish that you were larger? Smaller? Why? Yes, larger. Fight better.

12. Do you sit and dream about things when you are awake? Yes, fairy tales

13. In sitting, do you wiggle and squirm? Yes

14. Do you get tired easily? No

15. Do you like to go to bed at night? No

16. Do you have a hard time getting to sleep at night? Yes, I lie and think about things

17. Do you like to get up in the morning? No!

18. Do you talk about your friends to other people? Yes, lots

1 19. Do you always laugh when someone falls down? No.
When someone makes a mistake? Sometimes - it's funny.

20. Do you cry very often? What makes you cry? Yes. When mad or my feelings hurt. Or can't have my own way. Never when hurt.

21. Do you think that you have a bad temper? Yes, very - a Dutch one.

2 22. Do your parents treat you as well as they do your brother or sister? Better.
As well as other families treat their children? Better

| 23. Do you have an allowance? Is it large enough for you needs? No. Can have money whenever I want it

24. Do you wish that you did not have to go to school? Yes.

25. Do you think that policemen are usually fair? No! they arrested my Dad for speeding outside of city limits, and he wasn't going too fast. It wasn't fair there, or at Wayne either another time. You can't see city limit signs.

26. Do you like to talk about your troubles with other people? Yes. I went yesterday to see Miss W. in Detroit to talk over my Troubles, and get smarter.

| 27. Do you feel glad when a friend does something better than you could do? Yes.

| 28. Would you rather have light hair (if dark) or dark hair (if light)? No

29. Do you think that you talk louder than your friends? Yes, much.

| 30. Do you usually answer people the first time they call you? Yes

	31.	Do you think that it is fun to pretend?	Yes, about fairies, and fonts, and soldiers, and animals.
	32.	Do you eat a lot?	No, I only weigh 86.
	33.	Do you like most foods?	No, I hate lots of things.
	34.	Are your feelings easily hurt?	Very
1	35.	Do you sometimes feel glad one minute and sad the next?	No
	36.	Who is your favorite movie star?	Judy Garland, Errol Flynn, Mickey Rooney.
1	37.	Do you seem to break or tear more things than your friends?	No
1	38.	Have you ever fainted? When?	No
2	39.	Did you ever run away from home? Ever want to?	No No
	40.	Do you dream at night?	Yes, bad dreams usually. Last night Dad told me to count sheep. I count Tarzans swimming along trees to go to sleep. Sheep won't jump for me. I'm always falling in my dreams. It's a terrible sensation.
	41.	Do you bite your finger nails?	Yes, and pick them, Too.
	42.	Do you have a light on in your room before you can go to sleep?	Yes, in hall.

2 43. Do you have a dog, cat, or other pet? Dog
Do you always treat him nicely? Yes
Do you like to take care of him? No

44. Do you ever wish that you had never been born? Yes, when mad about not having my own way.

1 45. Do you comb your own hair? Sometimes

1 46. Do you use the telephone by yourself? Yes

1 47. Do you buy any of your own clothes? No
Pick them out? Yes

1 48. Do you ever feel that you almost hate yourself? No. I usually love myself.

49. What do you like to listen to on the radio? Jack Armstrong, Little Orphan Annie, Pinocchio, I Love a Mystery.

1 50. Do you have regular jobs to do at home? Yes, but usually I don't do them.
Enough? Yes, I mean no.

51. Would you like to be the brightest child in your room? No, but would like to be up with some of the other kids, though. You know in our room the best athletes are the dumbest, Joe and John. I'm third from bottom and I'm good in athletics, but NOT in schoolwork.

1 52. Do you ever stutter? No

2 53. Do you like to tease people? No
Like to be teased? No

1 54. Do you pick out your own books to read? Yes.

| 58. Do you usually do what you are told? Yes.

| 59. When you play games would you rather be Captain or just one of the players? Player

| 57. Do you like to have someone else tell you how to do things? Yes

58. Do you like to see automobile accidents? Yes, if no one hurt

59. Do you want your own way most of the time? Yes

| 60. Do you get stage fright? No

| 61. When do you think you have more fun?
When you are a little child?
When you are about ten? XX Have the most games
When you are grown up?

| 62. When you are talking to someone, do you talk a lot about yourself or mostly about other people or things? Things

63. When things go wrong do you get angry? Yes

| 64. Do you have spells of the 'blues'? No

65. Do you have a hard time making up your mind about things? Yes

66. Do you wish that you were a boy (if girl) or a girl (if boy)? Yes, because I'm lazy and girls don't have to work so much.

67. Do you like to go to parties? Yes, but I'm never invited, except once in a long time.

68. Are you lucky? Yes.

69. After you make up your mind not to do something do you ever do it anyway? Yes

70. Does your body ever seem stiff so that it hurts you to move around? Yes, I get terrible pains in my back and stomach when I bend over.

71. If you order something to eat in a restaurant and it is not good do you tell the storekeeper about it? No. Leave it, or have Dad tell them.

can be said that for the population studied there was stability of central tendency and of the amount of variation of affectivity for the two consecutive series of interviews. Changes which occurred in affectivity scores for individual children or for grade groups on the second interview as compared to the first thus operated within a stable central tendency for the total group.

In order to determine intrinsic reliability scores for all children the odd-numbered questions were correlated with scores on even-numbered questions in both series of interviews. For the first series this odd-even correlation of items as determined by the Pearson Product-Moment method was .70, expressing the reliability value for either half used singly. By applying the Spearman-Brown Probability formula, a value of .82 was obtained as an expression of the reliability of the total interview. For the second series with the reduced number of subjects the odd-even items correlated with a coefficient of .58, and a combined reliability of .74. These reliability values are considered adequate for the population studied, in so far as the scores derived reflect general trends in subjective areas for comparison with growth material.

Stability of affectivity scores for the same children at the time of the first and second interviews was determined by correlating their consecutive scores, in which case a coefficient of .70 was obtained.

The question as to whether the interviews as administered actually measure what they purport to measure, namely affectivity in children, has not been completely determined. For the purpose of this study, the general designation of affectivity has been applied to the interview findings.

RELATIONSHIP OF AFFECTIVITY TO OTHER MEASURES

Associational analyses were made between affectivity scores and various other measures, including organismic age, growth rate, organismic status (organismic age minus chronological age), organismic status excluding physical factors, mental age, educational age, developmental age, average deviation of all measures on a single child, problem tendencies and extroversion-introversion.

Organismic Age

Associational relationships were determined by applying the Pearson Product-Moment Correlation coefficient to affectivity scores and each of the other measures listed above.

Affectivity scores bore no definite relationship to organismic age for the group as a whole (Pearson r's for the two

series of scores were $-.04 \pm .08$ and $-.10 \pm .10$ respectively). It was then decided to separate the children into grade groupings to see if organismic maturity functioned in a social setting in such a way as to influence affectivity. The assumption was that children would be better able to sense their comparative organismic maturity in the group in which they lived than in the composite experimental group. By so doing the relationship between affectivity and organismic age was increased from -.04 to .32 for the first series of interviews and from -.10 to .19 for the second series. The children who ranked as more mature within their school grades tended to be happier as judged by affectivity scores. It would seem, then, that the sociologic sphere in which the subjects lived has some influence upon the level of affectivity. If this trend were to be substantiated with larger groups and repeated measures, it would have numerous implications for the classification and placement of pupils within the school organization.

Growth Rate

The Pearson r computed between the direction affectivity scores took between interviews and organismic growth rate (average growth rate per calendar month for all measures on each child) was $.37 \pm .09$. Thus, the suggestion emerges that children who are growing at a more rapid rate are somewhat happier than those who are growing more slowly.

It was further determined that affectivity scores were inclined to increase slightly during the interval between interviews for children whose rank in organismic age within their grade groups improved in the same interval. Affectivity scores decreased for those whose group status decreased.

It seemed plausible that a child might reflect affectivity in a change within his own rate of growth more than he would in a comparison of his own rate with the rates of others. Consequently, the growth rates of individual children for the duration of the experiment were compared with the growth rate which was typical for their complete school records. The Pearson r resulting from relating change in the child's growth rate during the experimental interval with change in affectivity during the same interval was $.45 \pm .08$. Thus, the direction of affectivity was influenced more by change within a child's own growth picture than by comparison with changes exhibited by the group as a whole.

Organismic Status

Since organismic age (the average age of all measures) did not in itself express acceleration or retardation, a method

was then devised to adjust for these factors. The child's chronological age was subtracted from his organismic age to obtain a positive or negative figure which would describe his status in relation to his age. For example, a child of 120 months whose organismic age is 129 months would have an organismic status of +9 months, indicating that he is 9 months accelerated in his organismic development.

It has already been shown that organismic age alone bears no apparent relationship to affectivity scores. It is also established that there is very little relationship between organismic status and affectivity scores (Pearson r .19 $\pm$ .08). If, however, the child's organismic status is compared with the organismic status of other children within his school grade, a trend emerges. Children with high affectivity scores tend to rank high within their grades in organismic status, and vice versa (Pearson r .42 $\pm$ .07 for the first series and .29 $\pm$ .09 for the second series). Thus, the sociological setting, in this case grade grouping, seems to influence affectivity with regard to organismic age and status. It would therefore seem that children become affectively aware of their organismic age and status only by comparison with the other children who comprise their groups and never by self-evaluation.

A correlation of .43 $\pm$ .08 was obtained between the direction affectivity scores took during the interval between interviews and change in organismic status in the same interval. This value may be interpreted as suggesting that while these children do not react affectively in any uniform way to absolute organismic status they do react to change. When this directional analysis was made within grade groups the resulting relationship is expressed by a Pearson r of .45 $\pm$ .08. Thus, children who improved their status improved slightly in affectivity, and children whose status suffered in the interval tended to decrease in affectivity.

Organismic Status Excluding Physical Factors

The analysis of organismic status data for individual children in the study suggested that the most accelerated children selected by this method were usually large in physical stature. At this point the assumption was made that possibly too great a premium was being given to large children and too great a penalty was being inflicted upon small children in so far as affectivity was concerned. Consequently, a new organismic status was assigned each child which excluded measures of height, weight, grip, dentition and wrist bone development and retained only the composite of mental achievement and personality factors. This composite status was then compared with chronological age in the same way as for the organismic status

data described in the preceding section. The Pearson r's obtained between this new organismic status which excluded physical factors were .43 ± .08 for the first series and .21 ± .09 for the second series.

When, however, organismic status excluding physical factors was related to the child's rank within his grade group, the relationship to affectivity rose to .55 ± .06 for the first series and .54 ± .09 for the second series. Grade classifications, therefore, seem to add significance to affectivity as related to organismic status in factors exclusive of physical ones. Likewise, affectivity seems to be more closely related to non-physical than to physical factors in the child's development.

Affectivity and Other Measures

Associational analyses such as those described above were made between affectivity scores and various other measures including mental age (Kuhlmann Binet), intelligence quotient, educational age (Stanford Achievement Test Scores), developmental age (Furfey-Sullivan Developmental Age Scales), average deviation of all measures, problem tendencies (Haggerty-Olson-Wickman Behavior Rating Schedules), and introversion-extroversion (Marston Scales).

The following additional relationships are thus described briefly:

1. No clear-cut relation was found between mental ages derived from Kuhlmann Binet tests and affectivity (Pearson r .09 ± .08 for the first series and .01 ± .10 for the second series).

2. When the children were separated into grade groups mental age and affectivity scores correlated positively (r's .38 ± .07 and .33 ± .09).

3. Children whose affectivity scores increased in the interval between interviews tended to gain more in mental age than those whose scores decreased (r .28 ± .09).

4. When the children were separated into grade groups the same positive trend persisted between increase in mental age and increase in affectivity scores (r .29 ± .09).

5. In order to hold the age factor constant, intelligence quotients were related to affectivity scores with resultant positive correlations for the two series of .25 ± .08 and .25 ± .09.

6. There was no discernible association between affectivity scores and Stanford Achievement Test educational ages for the population studied (r's .01 ± .10 and .03 ± .12).

7. When the children were separated into grade groups a positive relation was found between affectivity scores and educational age (r's .42 ± .08 and .29 ± .11).

8. A slight negative correlation (-.27 ± .11) was obtained between change in educational age and change in affectivity in the interval between interviews. However, a much smaller number of cases was involved (29) due to the lack of educational age measures for some of the youngest children each year.

9. Children with higher developmental ages as determined by the Furfey-Sullivan Developmental Age Scales tended to have slightly higher affectivity scores (r's .17 ± .13 and .06 ± .11).

10. When the children were separated into grade groups, developmental ages and affectivity scores correlated positively to the extent of .21 ± .13 and .10 ± .11.

11. Children whose affectivity scores increased in the interval between interviews tended to earn higher developmental ages at the time of the second rating (r .34 ± .12).

12. Children whose developmental age ranks within grades improved in the interval tended also to increase their affectivity scores (r .29 ± .12).

13. Affectivity scores did not reflect homogeneity or heterogeneity of growth pattern. Correlations of -.06 ± .08 and .13 ± .10 were obtained between average deviations of all measures and affectivity scores.

14. When grade groups were handled separately affectivity correlated very slightly with average deviation of all measures (r's .10 ± .08 and .04 ± .10).

15. It has already been shown that fast-growing children obtain slightly higher affectivity scores than do slow-growing children. It was further found that the average deviation of all measures was slightly higher for fast-growing children. A low positive correlation (.17 ± .10) between deviation of measures and affectivity scores lay therefore in the expected direction.

16. Children whose affectivity scores increased in the interval between interviews also tended to raise their average deviation ranks within their grade groups in the same interval (.19 ± .10).

17. Children with higher affectivity scores tended to exhibit fewer problem tendencies as rated by the Haggerty-Olson-Wickman Behavior Rating Schedule B (r's -.32 ± .07 and -.39 ± .08).

18. Children whose affectivity scores increased in the interval between interviews tended to receive slightly lower problem tendency scores at the second rating (r -.28 ± .09).

19. There was no apparent association found between affectivity scores and extroversion-introversion as measured by the Marston Scales (r's -.06 ± .08 and .08 ± .10).

THE RELATION OF AFFECTIVITY AND JOURNAL MATERIAL TO GROWTH IN SELECTED INDIVIDUAL CHILDREN

Relationships thus far described have been confined to groups. Evidence has been presented which suggests that affectivity scores do reflect growth levels, rates, and changes within groups.

Recent research in child development exhibits an increased awareness of the added information to be gleaned from studying individual children through time in addition to group comparisons.

In order to relate the nature of affectivity as measured by experimental interviews to total growth patterns in individual children, four cases have been chosen for special presentation. These four cases represent the four possible classifications to be made from affectivity scores.

a. The subject (case B 46) whose consecutive affectivity scores remained uniformly lowest in the population studied.

b. The subject (case B 34) whose consecutive affectivity scores remained uniformly highest in the population studied.

c. The subject (case G 31) whose consecutive affectivity scores decreased most markedly in the interval between interviews.

d. The subject (case B 2) whose consecutive affectivity scores increased most markedly in the interval between interviews.

Detailed descriptions of interview responses have been supplemented by records kept by the school psychologist, doctor, and teacher to portray the chosen four children as they impress the school personnel with whom they come into contact. Complete growth curves have then been drawn (Figures 1, 2, 3, and 4) to view the relationship of affectivity scores to the "whole child" point of view.

a. Case B 46 (Figure 1) is a boy whose consecutive affectivity scores were 44 (-1.4 sigma) and 42 (-1.5 sigma) which are uniformly low. At the beginning of the experiment he had a chronological age of 9 years and 3 months, a mental age of 9 years and 4 months, a reading age of 7 years and 11 months, a developmental age (Furfey Developmental Age Scale) of 10 years and 11 months, and an organismic age of 9 years and 7 months. His Haggerty-Olson-Wickman problem tendency score was 115, which is far above the mean in an undesirable direction (Norm for boys 72.4).

Figure 1 portrays B 46's complete growth picture from the time of his school entrance to the last available measure. Along the abscissa has been plotted his chronological age in months;

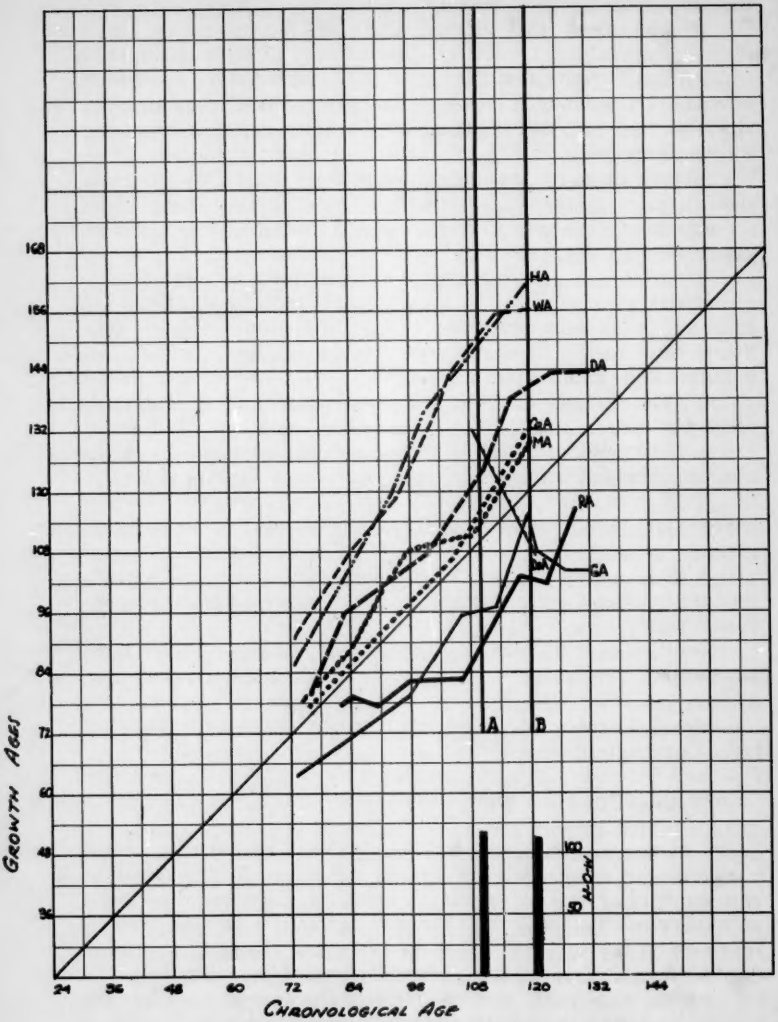

Figure 1. Growth record for boy (B 46) whose affectivity score remained uniformly low in the interval between interviews.

along the ordinate his growth ages as measured in months in the various areas indicated: HA (Height Age), WA (Weight Age), DA (Dental Age), CaA (Carpal Age), RA (Reading Age), DeA (Developmental Age), and GA (Grip Age). The perpendicular lines A and B represent the times at which the first and second affectivity interviews took place. The two dark perpendicular lines placed on the base line portray the Haggerty-Olson-Wickman Problem Tendency Scores obtained at the same time the interviews were scheduled. The solid diagonal line across the growth pattern represents a line of average; that is, it follows the line which a growth pattern would take if exactly average in all respects.

Thus, it can be seen that B 46 is a boy with uniformly low affectivity who presents a growth picture in which there is a marked discrepancy between his achievement and the rest of his development and whose behavior is often at variance with teacher and group standards. The segment of his growth pattern which falls between the two experimental interviews does not differ noticeably from other segments in the span presented. This is interesting since B 46 was chosen because his affectivity score remained uniformly low in the same interval.

Supplementary journal material on B 46 confirms the picture of maladjustment throughout. School staff members make frequent references to tensions, nervousness, parental discord, "sissiness," over-protection, nail-biting, daydreaming, unpopularity, insomnia, frustration in school work, hyperactivity, shortness of attention span, self-criticism, and a superfluous number of accounts describing behavioral difficulties.

From the "whole child" point of view, all above data seem to be in complete accord.

b. Case B 34 is a boy whose consecutive affectivity scores were 66 (+1.3 sigma) and 74 (+2.2 sigma) which are uniformly high. At the beginning of the experiment, he was 7 years and 5 months old, had a mental age of 9 years and 5 months, an educational age of 8 years and 9 months, and an organismic age of 7 years and 9 months. His Haggerty-Olson-Wickman problem tendency score was 51, which is far below the norms for boys in a desirable direction (Norm for boys 72.4).

Figure 2 shows B 34's growth pattern in the same way as for the preceding case of B 46. It is interesting to note that the curves off B 34 approximate a mirror image of those for B 46. All curves which fall below the line of average growth are physical measures, height age, weight age, and carpal age. B 34's problem tendency scores are shown along the base line and are seen to be uniformly low.

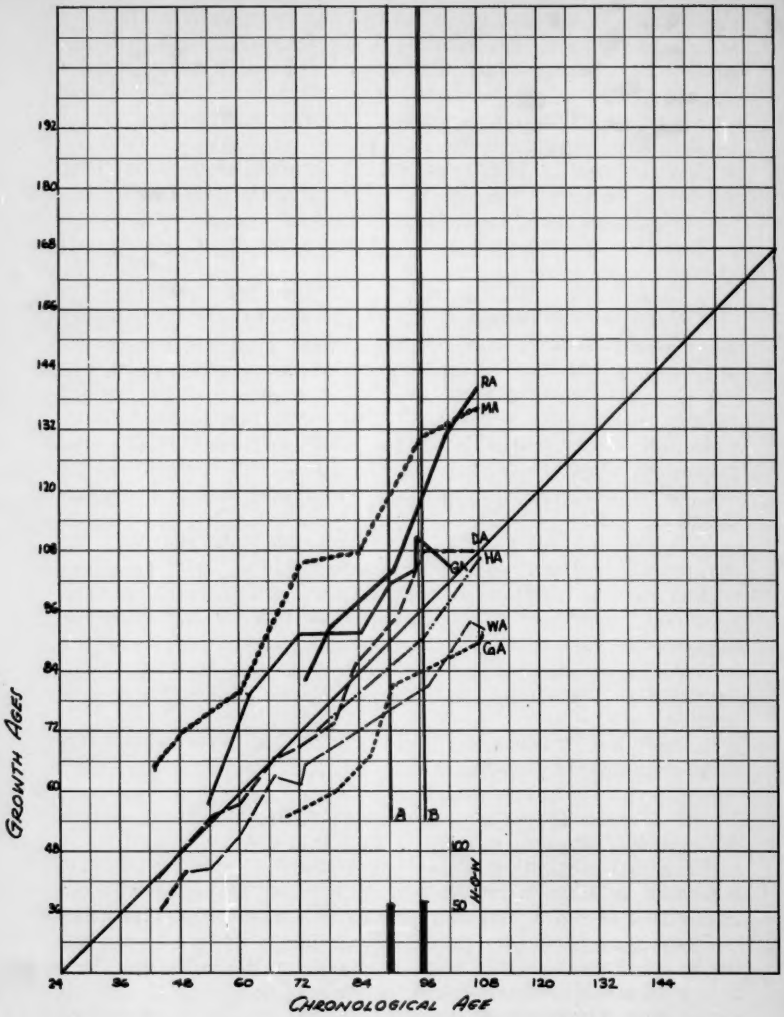

Figure 2. Growth record for boy (B 24) whose affectivity score remained uniformly high during the interval between interviews.

B 34, then, contrasts clearly with the preceding case. He is a small boy with high achievement and low problem tendencies. As in the case of B 46 there is no uniqueness of the growth segment between interviews as designated by perpendicular lines A and B. B 34 was chosen for special study because his affectivity score remained uniformly high in the experimental period, so the sameness of his concurrent growth picture is especially significant.

Supplementary journal material on B 34 stresses his leadership qualities, creativeness, excellence in academic areas, popularity, wide range of interests, poise, self-sufficiency, perseverance and general impression of well-being.

c. Case G 31 (Figure 3) is a girl whose consecutive affectivity scores were 70 (+1.9 sigma) and 54 (-.11 sigma) a decrease of 16 points, which is a marked decrease. At the beginning of the experiment she was 9 years and 8 months old, her mental age was 10 years and 10 months, her educational age was 8 years and 5 months, a developmental age (Sullivan Developmental Age Scale) of 11 years, and an organismic age of 9 years and 8 months. Her problem tendency score was 89, which according to the norm exceeds 89 per cent of other girls in an undesirable direction.

Figure 3 presents the growth data for G 31. Since she was chosen for her marked decrease in affectivity during the experimental interval it is interesting to note that the growth segment between interviews (A and B) contains more plateaux in development than does any other like segment in the span presented. Even height age, her most accelerated curve, is levelling off at this time. Obvious plateaux occur in carpal age, grip age, and mental age. A marked decrease is seen in developmental age during this period. G 31's problem tendency scores are seen to be consistently high, but even notwithstanding this fact they increase markedly in an undesirable direction in the period studied.

Journal recordings for G 31 likewise show a general increase in maladjustment factors during the experimental interval. During the first interview she was cooperative and friendly, speaking in short concise sentences. The psychologist, teacher, and doctor found little of interest to record at the time of the first interview, so that subjective material is mostly comprised of routine statements. In direct contrast with this lack of material at the time of the first interview, the journal records for the subsequent period (during which the marked decrease in affectivity took place) are to be found in abundance. Almost every school staff member had seen fit to record something about G 31 during this time. Items mentioned include dissatisfaction with the school, trouble with her classmates,

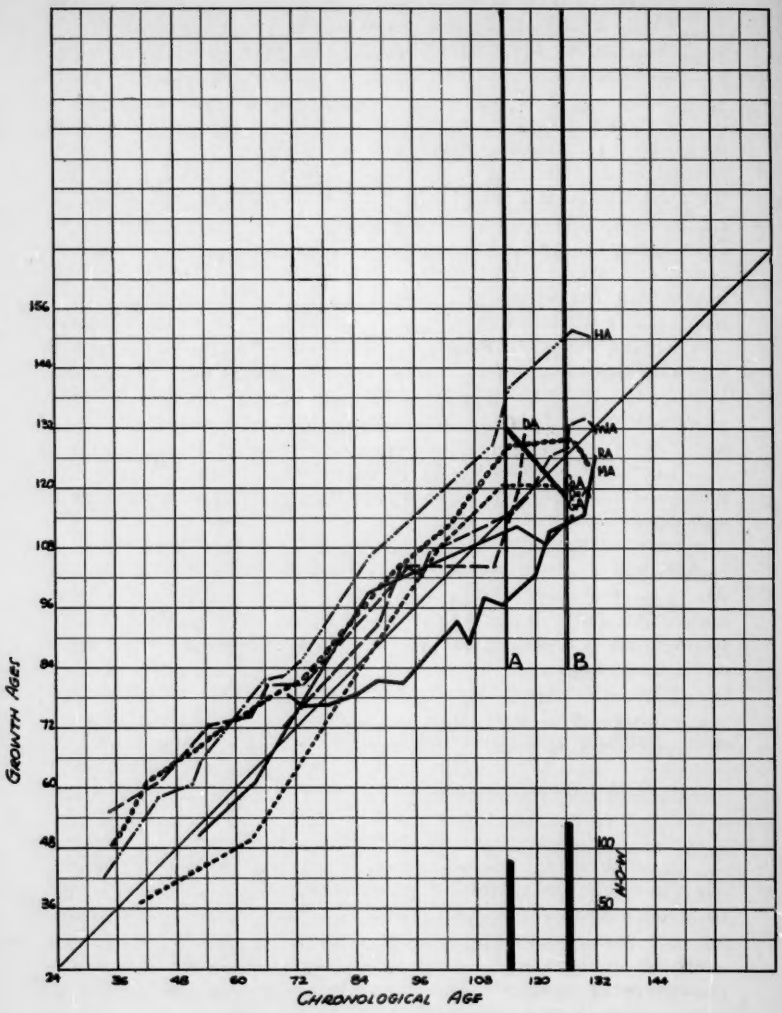

Figure 3. Growth record for girl (G 31) whose affectivity score decreased in the interval between interviews.

daydreaming, fatigue, depression, fainting spells, onset of adolescence, carelessness, and talkativeness.

Thus, in G 31 a marked decrease in affectivity is shown to be accompanied by a general regression in physical and adjustment factors.

d. Case B 2 is a boy whose consecutive affectivity scores were 41 (-1.76 sigma) and 53 (-.23 sigma), showing a gain of twelve points, which is a marked increase. At the beginning of the experiment B 2 was 10 years and 11 months old, his mental age was 11 years, his educational age was 11 years, his developmental age was 8 years and 11 months, and his organismic age was 11 years and 7 months. His problem tendency score was 78, which is slightly above the norm for boys in an undesirable direction.

Figure 4 portrays the complete growth pattern for B 2. Since he was chosen for his marked increase in affectivity it is interesting to note that the growth segment between interviews (A and B) contains more acceleration in development than does any other like segment in the span presented.

Likewise journal material available for B 2 reflects this general improvement. At the time of the first interview notes contain references to hyperactivity, restlessness, irritability, impulsiveness, persistence, comparisons with a more superior sister, and a strained ambitious attitude toward school work. At the second interview, mention is made of his frank, open and honest attitude, general improvement concerning attitudes toward school and home, popularity, calmness, cooperativeness and spontaneity.

Thus, B 2, whose gain in affectivity is the greatest, presents a constellation of physical, mental and social traits which is characterized by a general pattern of improvement.

FINAL STATEMENT CONCERNING AFFECTIVITY AND GROWTH

In general it can be said that for the population studied overt behavior and verbalized covert feelings bear demonstrated relationships to each other. These relationships are multiple and not confined to single correlations, in that many factors (such as achievement + mentality + maturity of interests + growth rate) seem to limit each measure of the relationship measured factors to affectivity.

Changes within the growth pattern seem to play a more important role in the analysis of affectivity data than does the study of status alone. It is extremely difficult to describe what a child's affectivity level will be at a given time by simply measuring his status in other factors. However, by determining

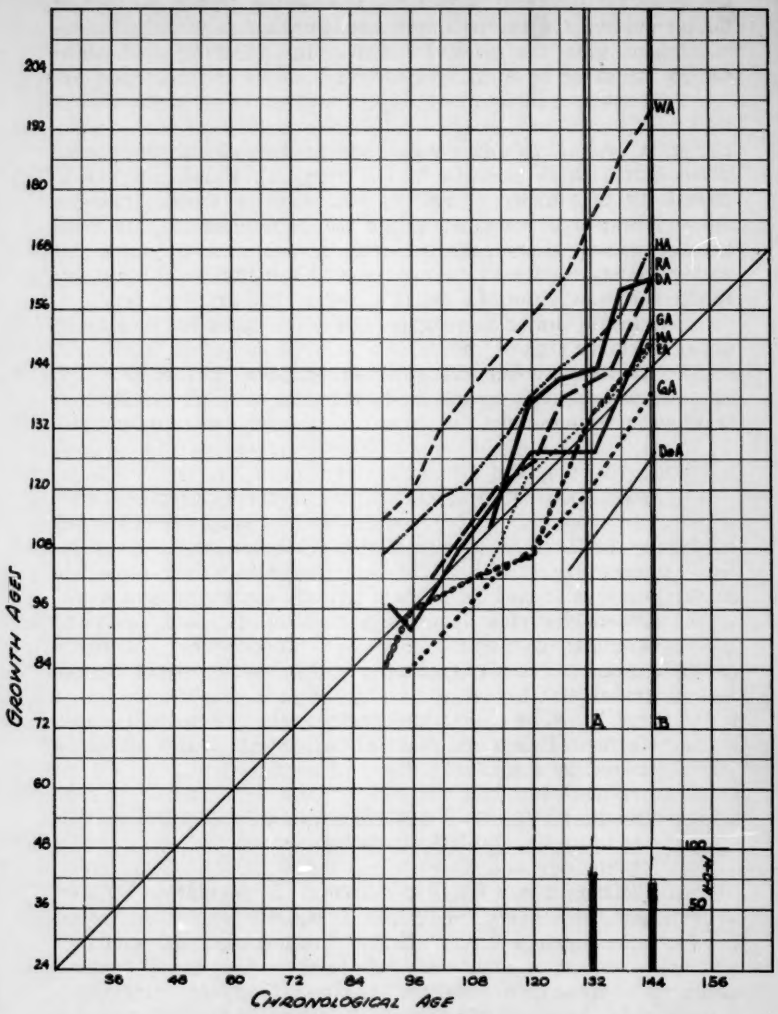

Figure 4.- Growth Record for Boy (B2) whose Affectivity Score Increased in the Interval between Interviews

Figure 4. Growth record for boy (B 2) whose affectivity score increased in the interval between interviews.

the general direction which his composite growth pattern is taking during a specified interval it is possible to fairly accurately describe the direction which his affectivity is taking during the same interval.

Affectivity seems to be a problem of group relativity as well as of status and change within growth patterns of individual children. Absolute measures such as mental age or educational age, which seem to bear very little relationship to affectivity in a group of children of varying ages will relate more closely to affectivity within a school grade where common standards and goals are shared. The impact of the entire social configuration seems to operate to color the child's affective reaction to single factors.

Within the limits of the experimental conditions, this study of the affective side of the child's development has tended to suggest further the importance of viewing the "whole child" in his field of operation and of recognizing the reciprocal effect of child and environment.[2]

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[2]*Microfilm copies of the complete study are on file in the University of Michigan Library and are obtainable through University Microfilms, 313 North First Street, Ann Arbor, Michigan.*

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